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The present part contains the chemistry of the oily acids, the fixed oils and fats, soaps and plasters, the essential oils, and the resins. In every one of these groups the reader will find the results of the most recent and accurate researches; and it will be perceived that in almost all of them additions have been made to our knowledge, of such extent and importance as completely to change the aspect of this branch of the science. In particular, the subject of the oily acids, with the fixed oils and fats, now assumes, for the first time, that appearance of distinctness and coherence which the chemistry of several other organic groups had previously exhibited. The subject, indeed, is far from being exhausted; but the results, which are here given in a condensed form, sufficiently show that we are now in the right path, and that, ere long, this part of the science will admit of the rigorous application of those general laws, hitherto supposed to be applicable only to inorganic chemistry, or at most to a few organic groups.

The Editor had hoped to include in this part the remaining subjects; but the necessity of new and rigid investigation in most of them has retarded the progress of the author. This delay, although in one point of view much to be regretted, is nevertheless not to be considered so injurious as under other circumstances it might have been. The interval has, as formerly, been occupied with researches, the result of which has been, in many instances, to make essential additions to our knowledge. It would have been easy to finish the work by giving merely what was known before the last great advances were made, the impulse of which continues to urge on the career of discovery in organic chemistry; but this proceeding would have exposed the work to the certainty of being in no long time a most unfaithful record of what is known. The subjects remaining to be treated are precisely those which were lately most obscure, and in which the most rapid progress has lately been made, and continues daily to be made.

These subjects are, the Vegetable colouring matters, the Vegetable alkalies, the Vegetable nitrogenised compounds, such as albumen, fibrine, gelatine, and gluten, and their *analogues* in the animal kingdom, and finally, the most interesting of all, namely, the changes which occur during the growth and nutrition both of animals and vegetables. The profound researches of Liebig and his school have already created what may be called a new science in this department; but the greater part of their results have not yet appeared. These results it is the anxious desire of the Editor to embody in the next and concluding part of this work; and he has great pleasure in stating, that, from the progress already made, he confidently hopes to be able to publish it in the end of autumn. No exertions shall be wanting on his part to enable him to attain this object.

The Editor is very sensible that in the present part many important subjects are treated too briefly; but the size to which the work has already attained, and the vastness of the matters to be comprised in it, have imposed on him the necessity of confining himself almost entirely to stating results. He has, however, been very careful to refer to the names of the authors consulted, whose memoirs are or will be contained in the Journals; especially in the Annalen der Chemie und Pharmacie, in Poggendorff's Annalen, and in the Annales de Chimie.

It may be mentioned here, that the recent invention of an easy and accurate method of determining the amount of nitrogen in organic compounds (not yet published) has given a new impetus to the progress of discovery in animal chemistry.

WILLIAM GREGORY.

King's College, Aberdeen,
26th July, 1841.

MECONIC ACID.

A tribasic acid. Symb. $\overline{Me}$.

Formula of the anhydrous acid, $C_{14}HO_{11}$ . . $= \overline{Me}$.
of the acid dried at 212°, $C_{14}HO_{11}+3HO$ $= \overline{Me}+3aq$.
of the crystallized acid, $C_{14}HO_{11}+3HO+6aq. = \overline{Me}+9aq$.

Seguin first observed that infusions of opium strike a blood-red colour with persalts of iron. Sertuerner first obtained a meconic acid (pyromeconic acid), by decomposing meconate of baryta with sulphuric acid, and subliming the acid obtained. Robiquet, in 1832, showed that the acid existing in opium differed from the sublimed acid, obtained it in a state of purity, and discovered the komenic acid.

To prepare meconic acid, pure meconate of potash is dissolved in 16 to 20 parts of hot water, and 2 to 3 parts of strong hydrochloric acid are added. On cooling, a quantity of crystals is deposited, chiefly acid meconate of potash ; these are treated a second time with water and hydrochloric acid, by which the potash is entirely removed. The crystals should leave no residue when heated on platinum foil. Boiling with hydrochloric or other acids must be avoided, as the acid is thus changed into komenic acid.

Meconic acid forms beautiful pearly scales, of a sour and astringent taste. They lose, when heated, 21 p. c. of water = 6aq. and become opaque. The crystals are sparingly soluble in cold water, much more so in hot water. When the solution is boiled for a long time, the acid is destroyed; and komenic acid, oxalic acid, carbonic acid, and a deep brownish-yellow colouring matter are formed. When boiled with strong hydrochloric acid, komenic and carbonic acids alone are formed. Animal charcoal absorbs meconic acid, and cannot be used to decolorize it. When the acid is exposed to heat, at 248° it is decomposed, yielding water and carbonic acid, while komenic acid is left. If the heat be increased, the komenic acid is resolved into pyromeconic and carbonic acids. Sulphuric acid acts on meconic acid in the same way as hydrochloric acid, but more slowly. Nitric acid decomposes it very rapidly. When boiled with an excess of caustic potash, meconic acid is entirely resolved into oxalic acid, carbonic acid, and a brown matter. (Liebig.) The persalts of iron are coloured of a deep blood-red by meconic acid or its salts. The acid is soluble in alcohol.

MECONATES.

Meconic acid forms with bases three kinds of salts, according as 1, 2, or 3 eq. of the hydratic water are replaced by metallic oxides. The general formulæ for these salts are as follows:

Monobasic Salts.	Bibasic Salts.	Tribasic Salts.
$\overline{Me}, \left.\begin{matrix}MO\\2HO\end{matrix}\right\}$	$\overline{Me}, \left.\begin{matrix}2MO\\HO\end{matrix}\right\}$	$\overline{Me},3MO.$

The only tribasic salt yet analyzed is one formed with oxide of silver. All the soluble monobasic and bibasic meconates have an acid reaction: the soluble tribasic salts have an alkaline reaction. The monobasic and bibasic salts of the alkalies and alkaline earths are sparingly soluble or insoluble: the tribasic are very soluble.

Meconate of Ammonia.—The monobasic and bibasic meconates of ammonia are crystallizable and have an acid reaction. An excess of ammonia produces tribasic meconate, which gives to the liquid a yellow colour.

Meconates of Potash.—$\overline{Me},2KO,HO$. The bibasic salt is obtained by adding caustic potash to a mixture of water with the impure meconic acid obtained from the meconate of lime (see below), till a greenish colour begins to appear. Heat is applied till the whole is dissolved; and, on cooling, the salt crystallizes in large quantity. It is purified by pressure, and repeated crystallization. It is sparingly soluble in cold water. Caustic potash added to its solution, produces a soluble tribasic salt which is yellow. If boiled with excess of potash, it is converted into oxalate and carbonate, while an intense colouring matter is formed. If treated with hydrochloric acid, it yields monobasic meconate in shining needles, $=\overline{Me},KO,2HO$.

Meconates of Soda.—In all respects analogous to the meconates of potash.

Meconates of Lime.—The insoluble bibasic meconate of lime is easily obtained from opium, by adding chloride of calcium to the infusion of that drug, as in the process of Gregory and Robertson, for preparing muriate of morphia. Its formula is $\overline{Me},2CaO,HO + 2aq$. It is used for preparing meconic acid by the following process, which is a modification of Robiquet's, proposed by Gregory. (Ann. der Pharm. xxiv. 43.) One part of this salt is mixed with 20 of water at 212°, and 3 parts of strong hydrochloric acid are added; the whole dissolves, and on cooling deposits monobasic meconate of lime, $\overline{\mathrm{Me}},\mathrm{CaO},2\mathrm{HO}+\mathrm{aq}.$ in silvery crystals. The sulphate of lime, which is always contained in the meconate of commerce in large quantity, is entirely retained in solution by the large excess of hydrochloric acid prescribed; which has also this advantage, that it causes the acid meconate of lime and the meconic acid to crystallize out almost entirely, hardly any being retained in solution. The crystals obtained in the first operation are again treated exactly in the same way, boiling being avoided; and the operation is repeated, if necessary, till the crystals, heated on platinum foil, leave no residue of lime. They are then coloured meconic acid, which is purified by being converted into meconate of potash, as above described; and from the pure meconate of potash the acid is extracted by a similar process, as already mentioned.

The *Meconates* of *Baryta*, *Magnesia*, and *Protoxide of Iron* have been described, but have little interest.

Meconate of Peroxide of Iron.—$\overline{\mathrm{Me}},\mathrm{Fe}_2\mathrm{O}_3$? This is a very soluble salt, of a deep red colour. Sulphurous acid and protochloride of tin decolorize it, especially with the aid of light. Owing to the intensity of its colour, the persalts of iron may be employed as tests for meconic acid, and hence of opium, the only substance in which meconic acid occurs.

Meconate of Lead.—$\overline{\mathrm{Me}}, 2\mathrm{PbO},\mathrm{HO}$. A white insoluble powder, sometimes used in preparing meconic acid.

Meconates of Silver. Bibasic.—$\overline{\mathrm{Me}},2\mathrm{AgO},\mathrm{HO}$. This salt is obtained by adding nitrate of silver to a solution of meconic acid. It is a heavy, white, insoluble powder. When boiled with water, it forms a yellow tribasic salt, while the water dissolves meconic acid. If heated, it leaves brilliant metallic silver. When boiled with diluted nitric acid, it yields cyanide of silver. (Liebig.)

Tribasic.—$\overline{\mathrm{Me}},3\mathrm{AgO}$. Meconic acid, slightly supersaturated with ammonia, gives with nitrate of silver a yellow precipitate of tribasic meconate of silver. (Liebig.)

KOMENIC ACID.

A product of the decomposition of meconic acid. A bibasic acid. Discovered by Robiquet. Formula of the crystallized acid, $\mathrm{C}_{12}\mathrm{H}_2\mathrm{O}_8+2\mathrm{HO}$. (Liebig.)

Komenic acid is formed from meconic acid, by the influence of heat, or the reaction of a powerful acid. It is also formed by simply boiling meconic acid with water; but in this way it is accompanied by an intense brown colouring matter, formed along with it. When meconic acid is boiled with strong hydrochloric acid, komenic acid is obtained almost colourless. The two acids have a close relation to each other. Meconic acid, containing its basic water, $C_{14}H_4O_{14}$, by losing 2 at. water, 2HO, and 2 at. carbonic acid, $2CO_2$, is converted into komenic acid, $C_{12}H_2O_8$, which takes up 2 at. of basic water.

Komenic acid forms hard crystalline grains, or crusts; its solution decomposes the carbonates, and produces a blood-red colour with the persalts of iron. When heated to 570°, it is resolved into pyromeconic acid, carbonic acid, and water.

KOMENATES.

Komenic acid forms two sets of salts with bases, the general formulæ of which are,

Monobasic Salts.		Bibasic Salts.
$\overline{Ko}+\left.\begin{matrix}MO\\HO\end{matrix}\right\}$	and	$\overline{Ko}+2MO.$

Of these salts little is known; the monobasic alkaline komenates are less soluble than the bibasic salts of the same bases. The monobasic komenate of silver is white, the bibasic yellow. Both have been analyzed by Liebig. (Ann. der Pharm. xxvi.)

PYROMECONIC ACID.

Formula of the crystallized acid, $C_{10}H_3O_5 + aq.$ (Robiquet.) It was discovered by Sertuerner, and long viewed as sublimed meconic acid, till Robiquet discovered the meconic acid, from which it is produced.

It is best obtained by distilling komenic acid at 570°. The latter, by losing 1 at. water and 2 at. carbonic acid, yields pyromeconic acid; $C_{12}H_4O_{10} = C_{10}H_3O_5 + HO + 2CO_2$. Towards the end of the distillation, feathery crystals of another acid condense in the neck of the retort, which Gregory considers to be komenic acid, perhaps regenerated. At all events, he found its properties very similar to those of komenic acid.

Pyromeconic acid crystallizes easily, either by sublimation, or from its solution in alcohol. It is very soluble, and strikes a red colour with the persalts of iron. According to Robiquet, it is so feeble an acid that it crystallizes unchanged out of a solution of potash. Its compound with oxide of lead is $C_{10}H_3O_5,PbO$; so that it seems to be a monobasic acid. Liebig has pointed out that its composition is the same as that of pyromucic acid; and thinks it probable that these acids may prove identical. The whole subject requires investigation.

TANNIC ACID.

Formula, $C_{18}H_5O_9 + 3HO$. Symb. $\overline{Qt} + 3aq$. Syn. Tannin; Acidum Quercitannicum.—It is found in every part, but especially in the bark, of all species of quercus, but in the greatest quantity in gall-nuts. To obtain it, coarsely powdered gall-nuts are acted on by ether, which has previously been shaken with water, in a percolator. In the bottle placed below are found two strata of liquid. The heavier is a saturated solution of nearly pure tannic acid in water; the lighter is a solution of gallic acid and of colouring matter in ether. The heavier liquid is gently evaporated to dryness, and leaves a shining porous mass of pure tannic acid. (Pelouze.)

It has usually a pale yellow colour, is very soluble in water, and has a purely astringent taste of singular intensity. It reddens vegetable blues. The solution, when heated in contact with air, absorbs oxygen, giving off an equal volume of carbonic acid, and is converted into gallic and ellagic acids. A moderately strong solution, when mixed with sulphuric, hydrochloric, phosphoric, arsenic, and boracic acids, yields precipitates, soluble in pure water and in alcohol, which are compounds of tannic acid with the other acids. (Berzelius.)

If the compound with sulphuric acid be dissolved with the aid of heat in diluted sulphuric acid, and boiled for a few minutes, the tannic acid disappears, and on cooling a large quantity of coloured crystals of gallic acid is obtained. An analogous change occurs when it is boiled with an excess of caustic alkali. (Liebig.)

Tannic acid combines with the skin of animals, forming an insoluble compound which does not putrefy. This is *leather*. By means of a bit of prepared skin, tannic acid may be entirely withdrawn from its solution in water. A solution of gelatine is precipitated by tannic acid in thick flocks, which dissolve when heated with the supernatant fluid. By the action of heat, tannic acid is converted into metagallic and pyrogallic acids.

TANNATES.

These salts are characterized by striking a deep bluish-black colour with the persalts of iron (*ink*). They do not precipitate gelatine till an acid be added. Tannic acid and the soluble tannates precipitate most of the organic alkalies in the form of white pulverulent compounds, insoluble in water, soluble in acetic acid. A solution of tannic acid, neutralized with potash, yields a thick precipitate, easily soluble in excess of potash; when this alkaline solution is boiled, it produces gallic acid and a brown colouring matter. The cold solution of tannate of potash rapidly absorbs oxygen from the air, and becomes brown.

Ammonia and soda act like potash. The tannates of baryta, strontia, lime, and magnesia are very sparingly soluble. Tannate of alumina is quite insoluble. The salts of protoxide of iron are not altered by tannic acid; but the mixture, when exposed to the air, absorbs oxygen, and becomes black. The black precipitate, formed with the persalts of iron is composed of $3\overline{Qt},Fe_2O_3,9HO$. (Pelouze.)

Tannate of Lead.— When acetate of lead is precipitated by tannic acid, and the precipitate boiled for some time with an excess of the salt of lead, it is changed into a sandy yellow powder, which is neutral tribasic tannate of lead, $\overline{Qt},3PbO$. (Liebig.) The precipitate formed in the cold, according to Berzelius, contains 34·21 p. c. oxide of lead.

Tannic acid produces with a solution of tartar-emetic a white precipitate, $3\overline{Qt},Sb_2O_3$.

The salts of tannic acid require a thorough investigation.

PRODUCTS OF THE DECOMPOSITION OF TANNIC ACID.

It has already been mentioned that tannic acid is readily converted into gallic acid and a brown matter, when boiled with acids or alkalies. The products of the distillation of tannic acid are the same as those of gallic acid; and this circumstance, with some observations of Robiquet, led to the idea that tannic acid contains gallic acid ready formed. An aqueous infusion of nut-galls gradually passes into gallic acid. Hitherto it is impossible to say what is the body which, united with gallic acid, forms tannic acid. According to Braconnot, nut-galls, powdered and moistened, undergo fermentation, yielding alcohol and carbonic acid, which would indicate the presence of sugar, a substance not yet observed in a free state in nut-galls; 3 at. of tannic acid contain the elements of 6 at. of gallic acid and 1 at. of grape sugar.

It is also remarkable that, according to Pelletier, a mixture of gallic acid and gum precipitates gelatine, which neither body separately does.

According to Pelouze, when a solution of tannic acid, by absorbing oxygen, is converted into gallic acid, an equal volume of carbonic acid is given off. If 8 at. oxygen be added to 1 at. tannic acid, we have the elements of 4 at. carbonic acid, 2 at. water, and 2 at. gallic acid, $C_{18}H_8O_{12}+O_8=4CO_2+2HO+2(C_7H_3O_5.)$ According to Erdmann, much ellagic acid is formed in this process. Tannic acid, treated with peroxide of manganese or of lead, is oxidized without the production of gallic acid.

There is reason to think that the brown matter produced when tannic acid is converted into gallic acid by the action of sulphuric acid is a secondary product of the decomposition of a colourless compound produced at first with the gallic acid. If from 1 at. of tannic acid we subtract 2 at. of anhydrous gallic acid, the remainder has the composition of hydrated acetic acid, or of sugar of starch. But acetic acid has been in vain sought for among the products of this reaction; and sugar of starch may be heated with sulphuric acid of the same strength without being decomposed or rendered brown.

The question of the pre-existence of gallic acid in tannic acid is interesting; but it must for the present remain undecided.

GALLIC ACID.

Formula of the crystals, $C_7HO_3+3HO=\overline{G}+3aq.$
of the acid dried at 212°, $C_7HO_3+2HO=\overline{G}+2aq.$
of the acid in the salt of lead, A, $C_7HO_3+HO=\overline{G}+aq.$
in the salt of lead, B, $C_7HO_3=\overline{G}.$

Discovered by Scheele. It exists ready formed in the seeds of the mango, and is a product of the decomposition of tannic acid. Its preparation has been described under tannic acid. The coloured crystals are purified by being combined with oxide of lead, and the compound decomposed by sulphuretted hydrogen. Here the sulphuret of lead acts like animal charcoal in removing the colouring matter.

It crystallizes in brilliant prisms, generally of a pale yellow colour. It is soluble both in water and alcohol, and does not precipitate gelatine. Its solution, exposed to the air, absorbs oxygen, gives off carbonic acid, and becomes brown and mouldy. The presence of alkalies hastens this change. Gallic acid colours the persalts of iron of a deep bluish-black; and forms with solutions of black oxide of iron a permanent black precipitate.

When gallic acid is dissolved in oil of vitriol with the aid of heat, it forms a carmine-red solution, which, when thrown into water, deposits a reddish-brown precipitate, which contains no sulphuric acid, and at 212° loses 10 p. c. water. When thus dried, it is gallic acid minus 1 at. basic water and 1 at. water of crystallization. Its formula is $C_7H_2O_4$. (Robiquet.) This substance is insoluble in water, soluble in alkalies. It may be made to yield the same tints to cloth as madder, with the same mordants. When heated, it yields vermilion-coloured crystals. When gallic acid is heated with a solution of chloride of calcium, carbonic acid is disengaged, and a crystalline powder is deposited, the composition of which is unknown. (Robiquet.)

Heat converts gallic acid into carbonic, pyrogallic, and metagallic acids.

GALLATES.

These salts are distinguished by the rapidity with which they are decomposed when exposed to the air in contact with free alkali. When a little gallic acid is added to an alkaline solution, it passes through yellow, green, red, and brown to black. This colour has sometimes erroneously been attributed to the presence of oxide of iron in mineral waters tested by gallic acid. The only gallates the composition of which is known, are the acid gallate of ammonia, and the gallates of lead.

Acid Gallate of Ammonia is obtained by neutralizing one-half of a solution of gallic acid with ammonia, adding the other half, and crystallizing. It forms short yellowish prisms; the composition of which is, $C_7HO_3,AdH_2O + C_7HO_3,2HO$; or $\bar{G},AdH_2O + \bar{G},HO + aq.$

Acid Gallate of Lead is obtained by adding acetate of lead to a warm solution of gallic acid, leaving an excess of the latter. A white precipitate falls, which, if left in the liquid, changes into a grey crystalline powder. When dried at 212°, it contains $2\bar{G},PbO, HO + aq$.

Basic Gallate of Lead is obtained by adding a solution of gallic acid to a boiling solution of acetate of lead, the latter being in excess. It is a flocculent white precipitate, which when boiled becomes grey and crystalline. Its formula is $\bar{G},2PbO$.

The gallates of potash, soda, and of the protoxides of manganese, iron, zinc, cobalt, and nickel are soluble. The rest are insoluble.

ACTION OF HEAT ON GALLIC AND TANNIC ACIDS.

When tannic acid is distilled by a quick fire, it froths and melts into a black viscid liquid, which, after the heat has been continued for some time, becomes solid. The volatile products are carbonic acid, water, and crystals of pyrogallic acid. The solid residue dissolves in alkalies, and is precipitated by acids as a black powder, which Pelouze calls *Metagallic Acid*, but for which Berzelius proposes the name of *Melangallic Acid.*

When gallic acid is kept for a long time at a heat of 410°, it is changed into a grey powder, which dissolves in hot water, and on cooling yields reddish-coloured crystals of an astringent taste. If gallic acid be heated to 440°, it melts, and leaves a shining black mass, which is soluble in water, and tastes like catechu. It precipitates gelatine; but does not, like tannic acid, precipitate the organic alkalies. At a still higher temperature metagallic acid is formed. The volatile products are the same as those of tannic acid.

PYROGALLIC ACID.

Formula, C_2HO, when reduced to the simplest form. It is uncertain whether its equivalent be $C_6H_3O_3$, or $C_8H_4O_4$. Its preparation by heating tannic or gallic acids has been described.

It forms shining scales or needles, of a bitter and astringent taste; is neutral to test paper, and melts at 240°, boils at 410°, and sublimes unchanged. If suddenly heated to 480°, it is converted into water and metagallic acid; a higher temperature produces carbon and empyreumatic products. It is soluble in water; and reduces gold, silver, and mercury from their solutions. It strikes a bluish-black colour with salts of protoxide of iron, and also with the persalts of iron, which are reduced thereby to protosalts.

Of pyrogallic acid so little is known, that it is even doubtful if it possess acid properties. It stands to gallic acid in the same relation as acetone to acetic acid.

PYROGALLATES.

Of these salts, only the pyrogallate of lead has been examined by Berzelius, Pelouze, and the late R. C. Campbell, of Glasgow. According to the two former, the precipitate formed by adding pyrogallic acid to acetate of lead is $C_6H_3O_3 + PbO$. According to Campbell it is $C_8H_4O_4 + PbO$.

All the salts of pyrogallic acid, in contact with an excess of alkali, undergo a change similar to that of the salts of gallic acid. Pyrogallic acid, neutralized with potash, strikes a deep blue with the persalts, and a bluish-black with the protosalts of iron.

METAGALLIC ACID.

Formula of the anhydrous acid, $C_6H_2O_2$. (Pelouze.) Probable atomic weight, $C_{12}H_3O_3 + HO$.

It is a product of the decomposition of tannic, gallic, and pyrogallic acids, and its preparation has been already described.

It forms a black powder, soluble in alkalies. These solutions have a black colour, and cause black precipitates in solutions of lead and silver. The salt of silver is $C_{12}H_3O_3 + AgO$.

CONSIDERATIONS ON THE FOREGOING FACTS.

Tannic and gallic acids, although of very different composition, yet yield the same products, only in different proportions, by the action of heat; namely, metagallic, pyrogallic, and carbonic acids, and water.

Tannic acid may be viewed as a compound of gallic and pyrogallic acids.

3 at. tannic acid; $3(C_{18}H_8O_{12})$=6 at. gallic acid; $6(C_7H_3O_5)$+2 at. pyrogallic acid, $2(C_6H_3O_3)$.

Now, since gallic acid contains the elements of carbonic and pyrogallic acids, or of carbonic acid, metagallic acid, and water, it is easy to see how all these products may be formed. The proportions, however, differ with the temperature. This renders it difficult to represent all the changes by one simple equation.

It is plain, however, that tannic, gallic, and pyrogallic acids, like the three acids described under meconic acid, have an intimate connection. Further experiments must decide in what form the carbonic and pyrogallic acids exist in the tannic and gallic acids.

NUT-GALLS. ELLAGIC ACID.

From the puncture of an insect (Cynips gallæ tinctoriæ, Olivier) there is produced, on the leaves of all species of quercus, the so-called Nut-galls. These, when of good quality (Aleppo galls), contain 30 to 50 per cent. of soluble matter, chiefly tannic acid.

The alcoholic or aqueous infusion of nut-galls is known by the name of tincture of galls. It contains variable proportions of tannic and gallic acids, and is used as a test.

It precipitates persalts of iron of a deep bluish-black colour; tin, yellowish; nickel, greenish-yellow; cobalt, whitish-yellow; cerium, yellow; copper, grey; titanic acid, red; tellurium, yellow; antimony, white; columbium, reddish-yellow; chromium, brown; molybdenum, brown; lead, white; uranium, reddish-brown; bismuth, reddish; silver, dirty yellow; platinum, dark green; gold, brown; osmium, violet.

A fresh infusion precipitates the salts of cinchonine, quinine, brucine, strychnia, codeine, narcotine, and morphia, all white. These precipitates are soluble in acetic acid.

When the infusion of nut-galls is exposed to the atmosphere, the tannic acid gradually disappears, and is replaced by gallic acid and a insoluble grey powder. Chevreul found that this powder was soluble in alkalies, and precipitated by acids; he called it Ellagic acid (from *Galle* reversed). Braconnot observed, that it is formed in large quantity when nut-galls, moistened, are made to undergo fermentation. It forms with potash a crystallizable salt, insoluble in water, but soluble in alkalies. According to Pelouze, its formula is $C_7H_2O_4 + HO = C_7H_3O_5$, which is the composition of gallic acid dried at 212°. In the anhydrous state it has the same composition as the compound described by Robiquet as produced by the action of sulphuric acid on gallic acid; from which, however, it differs in its colour, and in the insolubility of its compound with potash.

Ellagic acid, when heated, yields a greenish-yellow vapour, which condenses into greenish-yellow crystals, which are soluble without change in sulphuric acid and alkalies, and are dissolved by nitric acid with a red colour, being converted into oxalic acid when the solution is heated for some time.

Grischon has found ellagic acid in the root of tormentilla officinalis.

COMPOUNDS OF UNKNOWN CONSTITUTION SIMILAR IN THEIR RELATIONS TO TANNIC ACID.

Cinchona bark, catechu, and kino, the barks of the pine tribe, and many other vegetables, contain substances analogous to tannic acid, in so far as they are astringent, and are capable of combining with animal skin and gelatine. They differ from it, however, principally in causing a dark green or a grey precipitate with the persalts of iron; for which reason the name of *tannin which precipitates iron green*, and of *tannin which precipitates iron grey*, have been given to them collectively.

The experiments of Geiger, Berzelius, and Waltl tend to prove that the tannic acid in all plants is essentially the same; and that the green and grey colours of the precipitate with salts of iron are owing to the presence of free acid, since the addition of a minute quantity of alkali changes these into the usual bluish-black caused by pure tannic or gallic acids.

CATECHU.

The substance known in commerce under the name of catechu is the dried watery extract of *mimosa catechu*. (Willdenow.) It is astringent and bitter, with a sweetish after-taste. It contains a considerable quantity of tannic acid, soluble in cold water, and very similar in its properties to that from nut-galls. Hitherto, however, it has not been observed to yield when heated the same products as ordinary tannic acid. This modification of tannic acid requires a careful investigation.

CATECHINE.

The portion of catechu which is insoluble in cold water contains a peculiar principle, catechine or tanningenic acid, discovered by Büchner. It is soluble in hot water and in alcohol. The colouring matter dissolved along with it is removed by adding acetate of lead till the liquid becomes colourless, precipitating the lead by sulphate of soda, and allowing the clear liquor to cool, when the catechine is deposited. It can only be safely filtered through paper purified by hydrochloric acid from oxide of iron and lime, as it is coloured by contact with these bases.

Catechine forms a fine white powder composed of silky needles, fusible in a moderate heat, decomposed by a higher temperature. According to Büchner, if heated till it becomes brown, it is changed into tannic acid. It is very sparingly soluble in cold water. Its solution is coloured red by long exposure to the atmosphere, and if now evaporated leaves a red splintery mass, soluble in cold water. Catechine colours green the persalts of iron. It does not precipitate gelatine, tartar-emetic, or vegetable alkalies. According to Svanberg, its formula is $C_{15}H_6O_6$. This requires confirmation.

When exposed to the air in contact with caustic alkalies, it forms black solutions; with carbonated alkalies, red solutions. According to Svanberg, the former contain a new acid, ***Japonic Acid***, in combination with the bases; the latter, another new acid, ***Rubinic Acid***.

Japonic acid, when separated from its salts, forms a black powder, soluble in hot water. Its formula is $C_{12}H_4O_4 + aq$. That of the japonate of silver is $C_{24}H_8O_8 + AgO$. (Svanberg.) According to this, 2 at. of acid lose 2 at. of water, which are replaced by 1 at. oxide of silver. This is rather improbable.

Rubinic acid has not been obtained in a separate form. Its formula, as it exists in the rubinate of silver, is $C_{18}H_6O_9$. (Svanberg.) The production of these compounds is not yet explained.

According to Pelouze, ether dissolves out of dry catechu a species of tannic acid, the formula of which is $C_{18}H_9O_8$. It remains to be determined whether this is catechine; from which, however, in the present state of our knowledge, it appears to differ in composition.

CITRIC ACID.

A tribasic acid. (Liebig.)

A. Formula in the salt of silver . . $C_{12}H_5O_{11}=\overline{\overline{\overline{\mathrm{Ci}}}}$

B. Formula of the acid dried at 212° . $C_{12}H_5O_{11}+3HO=\overline{\mathrm{Ci}}+3$ aq.

C. Formula of the acid crystallized by cooling $C_{12}H_5O_{11}+3HO+aq=\overline{\mathrm{Ci}}+4$ aq.

D. Formula of the acid formed at 61° . $C_{12}H_5O_{11}+3HO+2aq=\overline{\mathrm{Ci}}+5$ aq.

Discovered by Scheele in 1784. It is found in the juice of many fruits, particularly those of the different species of *citrus*, *vaccinium*, and *ribes*.

To obtain it, citrate of lime is formed by adding chalk to lemon juice; and this salt is afterwards decomposed by diluted sulphuric acid in slight excess, and the citric acid purified by crystallization. It is made in large quantity for the calico printers, and for medical purposes, and may be purchased at a cheap rate in a high degree of purity. It is chiefly used in medicine as an ingredient in effervescing powders.

It forms regular transparent crystals, very soluble, of a pleasant acid taste, which differ in the amount of water when formed at different temperatures, as in the above table. The acid D loses two atoms of water at 212°, and is converted into the acid B. The acid C does not lose water, even at 266°. All the modifications melt by heat; and if the heat be removed as soon as other products besides water appear, there is left a transparent deliquescent mass, which is a mixture of citric and aconitic acids. A higher temperature causes the production of carbonic oxide, carbonic acid, acetone, acetic acid, and two pyrogenous acids, with a trifling residue of carbon when the heat has been strong and rapidly applied.

By the action of oil of vitriol, aided by heat, citric acid is resolved into carbonic oxide, carbonic acid, acetic acid, and water, the elements of which it contains.

When melted with an excess of caustic potash, it is resolved into oxalic and acetic acids and water, which is merely a different arrangement of the same elements.

By oxidizing agents in general citric acid is partially converted into acetic acid.

When a few drops of a solution of citric acid are added to lime water, a clear liquid results, which, when heated, deposits a white powder, soluble in acids without effervescence.

CITRATES.

Citric acid forms with bases neutral and basic salts. The formula of the neutral tribasic salts is $\overline{\mathrm{Ci}}+3\mathrm{MO}+\mathrm{aq.}$, and they correspond to the acid C, its basic water being replaced by an equivalent of protoxide. They contain, besides, 1 at. of water of crystallization, which they lose when heated. Their formula then is $\overline{\mathrm{Ci}}+3\mathrm{MO}$, corresponding to the acid B.

In the basic salts, either the water of crystallization of the neutral salts is replaced by an equivalent of protoxide, $\overline{\mathrm{Ci}}+3\mathrm{MO}+\mathrm{MO}$, being thus also analogous to the acid C; or else, in addition to this, they contain 1 at. water of crystallization, $\overline{\mathrm{Ci}}+3\mathrm{MO}+\left.\begin{matrix}\mathrm{MO}\\ \mathrm{HO}\end{matrix}\right\}$, in which case they correspond to the acid D.

The only bibasic citrate yet examined is that of lead, in which 2 of the 3 at. of basic water of the acid D are replaced by oxide of lead.

The citrates, when heated, froth, blacken, and give off an acid liquid.

When an anhydrous citrate, $\overline{\mathrm{Ci}}+3\mathrm{MO}$, is decomposed by an alcoholic solution of hydrochloric acid, so that each equivalent of citric acid can only obtain 3 eq. water, formed by the oxygen of the oxide, and the hydrogen of the hydrochloric acid, the citric acid resolves itself into hydrated aconitic acid, and the citric acid C; thus,

$$\begin{array}{ll}
\text{3 at. hydrated aconitic acid} & C_{12}H_{6}\,O_{12}=3(C_{4}\,HO_{3}+\mathrm{aq.})\\
\text{2 at. citric acid} \quad . \quad . & \underline{C_{24}H_{18}O_{30}=2(C_{12}H_{5}O_{11}+3HO+\mathrm{aq.})}\\
 & C_{36}H_{24}O_{42}=3(C_{12}H_{5}O_{11}+3HO.)
\end{array}$$

This is the same change which is produced by heat. (Berzelius.)

Citrate of Ammonia is a very soluble and crystallizable salt, not particularly examined.

Citrate of Oxide of Ethule.—Formula, $\overline{\mathrm{Ci}},3\mathrm{AeO}$. (Dumas.) Discovered by Thenard. It is obtained by heating a mixture of citric acid, alcohol, and oil of vitriol, till ether begins to distil over. When the residue in the retort is mixed with water, the citric ether separates as a heavy oily fluid. It is washed with water, dissolved in alcohol, and decolorized by charcoal. The alcohol being dissipated by heat, leaves the new ether pure. It has a faint smell of olive oil, and a bitter taste. Sp. g. = 1·142. It boils at 540°, but is partially decomposed; yielding carbon, pyrocitric acid, and alcohol. It is converted by alkalies into citric acid and alcohol; but is not altered by acids in the cold, nor by chlorine and bromine.

The monobasic and bibasic citrates of ethule are not known. The citrates of methule and glycerule, &c. are also unknown.

Citrate of Potash.—Three citrates of potash exist, $\overline{Ci},3KO$; $\overline{Ci},2KO,HO$; and $\overline{Ci},KO,2HO$. They are soluble and crystallizable, but have not been further investigated.

Citrate of Soda.—Formula of the tribasic salt, $\overline{Ci},3NaO$, 11 aq. (Berzelius.) This salt forms large regular crystals. At 212° they lose 7 at. water, leaving $\overline{Ci},3NaO,4aq$. When heated to from 360° to 380°, the remaining 4 at. water are expelled; but a portion of the salt is converted into aconitate of soda.

The bibasic salt, $\overline{Ci},2NaO,HO$, is obtained by adding to a solution of the last salt half as much citric acid as it already contains. By spontaneous evaporation it forms small prismatic crystals.

The monobasic salt, $\overline{Ci},NaO,2HO$, is obtained by a similar process, adding a quantity of citric acid equal to that already present. It forms a gummy amorphous mass; but may be obtained in crystalline grains from an alcoholic solution.

Citrate of Baryta.—Two forms of this salt are known. Citrate of soda added to chloride of barium causes a white precipitate, $\overline{Ci},3BaO,7aq$. (Berzelius.) A heat of 300° expels 6 at.; a higher temperature the last atom of water. When a hot solution of citric acid and chloride of barium is added to a hot solution of citrate of soda till the precipitate is dissolved, and the mixture allowed to cool, a crystalline powder is deposited, which contains $2\overline{Ci},5BaO,HO + 7aq$. and must be viewed as a compound of the salt first described with a bibasic salt, $\overline{Ci},2BaO,HO$.

Citrate of Lime.—The tribasic salt, formed like that of baryta, is $\overline{Ci},3CaO,4aq$. (Berzelius.) The precipitate formed by heating citric acid with an excess of lime-water is a basic salt, $\overline{Ci},3CaO, + \left.\begin{matrix}CaO\\HO\end{matrix}\right\}$. At 212°, it is converted into $\overline{Ci},3CaO,CaO$. The salt formed by adding chalk to lemon or currant juice, from which citric acid is obtained, is a mixture of the two salts just described.

Magnesia, alumina, and protoxide of manganese, each form with citric acid an insoluble tribasic and a soluble monobasic or bibasic salt. The citrate of protoxide of iron is crystallizable; that of the peroxide is brown and soluble. Citrate of zinc is sparingly soluble.

Citrate of Lead.—The tribasic salt, $\overline{Ci},3PbO,aq.$ is a white powder, resolved, by washing with water, into the soluble bibasic salt, and an insoluble salt with excess of base. The bibasic salt, $\overline{Ci},2PbO,HO, + 2aq.$ forms crystalline grains. The basic citrate of lead occurs in two forms; the first is $\overline{Ci},6PbO$: the second

$$\left.\begin{matrix}\overline{Ci},3PbO,PbO\\ HO\end{matrix}\right\}.$$

The only citrate of copper yet described is a green crystalline powder, $\overline{Ci},3CuO,CuO = \overline{Ci},4CuO$. It contains, therefore, an excess of base.

Citrate of Silver forms a brilliant white powder, which, if washed and dried below 60°, is $\overline{Ci},3AgO,aq.$ When gently heated, it gives off water, and becomes $\overline{Ci},3AgO$.

Potash-citrate of Antimony.—This salt, which has properties analogous to tartar-emetic, forms dazzling white prisms. It is composed of $\overline{Ci},Sb_2O_3 + \overline{Ci},3KO + 5aq.$ (Thaulow.) The water is expelled at 375°.

ACTION OF HEAT ON CITRIC ACID.

This subject has occupied the attention of Lassaigne, Dumas, Baup, Robiquet, Dahlström, and Berzelius; but the products vary so much with the circumstances of the experiment, that their results appear contradictory and irreconcileable. The very recent researches, however, of Crasso (Liebig's Annalen, April 1840) have cleared up the whole subject, and reconciled the contradictions of his predecessors. We have only space for his results.

According to Crasso, then, crystallized citric acid, when exposed to heat, exhibits four stages of decomposition. During the first, the water of crystallization alone is given off, and the residue contains unaltered citric acid. The second stage is characterized by white vapours, and the production of acetone, carbonic oxide, and carbonic acid, while the residue consists of hydrated aconitic acid, which is therefore the true pyrocitric acid. In the third stage, the aconitic acid, not being volatile, is itself decomposed, yielding carbonic acid, and an oily liquid, which soon crystallizes. This is the pyroaconitic acid, the citricic acid of Baup, for which Crasso proposes the name of Itaconic acid. In the fourth period, empyreumatic oil is produced, and a voluminous coal remains behind. Crasso has further shown that the aconitic acid, heated by itself, is converted into itaconic acid and carbonic acid; and that the itaconic acid, when heated, yields a volatile acid isomeric with itself, which is identical with the citribic acid of Baup, which he proposes to call Citraconic acid, and which is always more or less formed along with the itaconic acid, owing to the easy decomposition of the latter. The action of heat on citric acid, therefore, gives rise to three distinct acids in regular sequence; 1st, aconitic or pyrocitric acid; 2nd, itaconic or pyroaconitic acid; 3rd, citraconic or pyro-itaconic acid.

ACONITIC ACID.

Formula, $C_4HO_3 + \text{aq}$. Symb. $\overline{\text{At}} + \text{aq}$.

This acid was discovered by Peschier, in the *aconitum napellus*, and analyzed by L. A. Buchner, jun. The acid observed by Braconnot in *equisetum fluviatile*, and analyzed by Regnault, seems to be identical with it; as does also the acid obtained from citric acid by Berzelius and Dahlstrom, as above described. It is easily extracted from the plants, by combining it with oxide of lead, decomposing the salt by sulphuretted hydrogen, and purifying the acid by solution in ether.

It forms a white crystalline mass, soluble in water, of a pleasant acid taste. It is decomposed by heat, yielding two new acids. Regnault supposed it to be identical with maleic acid; but as the latter is converted by heat into fumaric acid, a change not observed in aconitic acid, this identity is doubtful. It ought to be mentioned also, that the acid from equisetum fluviatile may be sublimed without change, although in all other particulars identical with the acid from aconitum napellus.

Its production is easily explained, for 1 at. anhydrous citric acid, $C_{12}H_5O_{11}$, yields

$$\begin{array}{ll}
\text{1 at. aconitic acid} & =C_4\,H_2O_4=C_4HO_3+HO. \\
\text{1 at. acetone} & =C_3\,H_3O. \\
\text{4 at. carbonic oxide} & =C_4\quad O_4. \\
\text{1 at. carbonic acid} & =C\quad\ O_2. \\
\hline
\text{1 at. anhydrous citric acid} & =C_{12}H_5O_{11}.
\end{array}$$

As above mentioned, this is the true pyrocitric acid.

ACONITATES.

The alkaline aconitates are soluble in water, the others insoluble or sparingly soluble. Their properties are not very interesting. The general formula for these salts is $\overline{\mathrm{At}}$,MO. They sometimes contain water of crystallization.

There is some reason to believe that this acid may prove to be tribasic. It will then have the formula $C_{12}H_3O_9 + 3HO$; and the neutral aconitates will have the formula $C_{12}H_3O_9 + 3MO$. Future investigations must determine this point.

ITACONIC ACID.

Syn. Pyrocitric Acid; Citricic Acid. (Baup.) Formula, $C_5H_2O_3 + HO$. Symb. $\overline{\mathrm{It}} + \mathrm{aq}$.

This acid is obtained, as above mentioned, in the third stage of the distillation of citric acid, or by the action of heat on aconitic acid. It is generally accompanied by some of the acid next to be described, citraconic acid. It may be obtained from the oily mass which distils over, and which commonly crystallizes after a short time, by solution in absolute alcohol, and spontaneous evaporation. The crystals thus obtained, when dissolved in water, yield by slow evaporation large rhomboidal crystals, or octahedrons, soluble in 17 parts of water at 60°.

There is some reason to suppose that it may be a bibasic acid, in which case its formula will be $C_{10}H_4O_6 + 2HO$. In the production of this acid from aconitic acid, 3 at. hydrated aconitic acid, $3(C_4HO_3 + HO) = C_{12}H_6O_{12}$, yield 2 at. carbonic acid, $2CO_2$, and 2 at. itaconic acid, $2(C_5H_2O_3 + HO)$.

ITACONATES.

The neutral itaconates have the general formula $C_5H_2O_3 + MO$, or $C_{10}H_4O_6 + 2MO$. The acid salts are either $2(C_5H_2O_3) + MO + HO$, or $C_{10}H_4O_6 + \left.\begin{matrix}MO\\HO\end{matrix}\right\}$. They have been studied by Baup and Crasso, to whose memoirs the reader is referred for details.

CITRACONIC ACID.

Syn. Pyrocitric Acid; Citribic Acid. (Baup.) Formula, $C_5H_2O_3 + HO$. Symb. $Ct + aq$.

This acid is formed by the action of heat on itaconic acid, with which it is isomeric. It is volatile, and thus escapes the further action of the heat. It is soluble in less than half its weight of water at 60°, and very soluble in alcohol and ether. It is very probably also a bibasic acid, having the formula $C_{10}H_4O_6 + 2HO$; but this must be determined by future researches.

CITRACONATES.

Citraconic acid forms neutral and acid salts, which have been examined by Crasso. The neutral salts have the general formula $C_5H_2O_3 + MO$, or $C_{10}H_4O_6 + 2MO$. The acid salts are either $2(C_5H_2O_3) + HO + MO$; or $C_{10}H_4O_6 + \left.\begin{matrix}HO\\MO\end{matrix}\right\}$. It forms with ammoniacal gas a peculiar amorphous compound, which does not contain the water usually present in ammoniacal salts. The formula of this compound is $2(C_5H_2O_3) + NH_3$. When this substance is dissolved in water, and the solution evaporated, it yields crystals of the acid citraconate of ammonia, $2(C_5H_2O_3) + NH_2O + HO$. (Crasso.)

TARTARIC ACID.

A bibasic acid. Formula of the crystallized acid, $C_8H_4O_{10} + 2\ aq.$; of the acid in the bibasic salts, $C_8H_4O_{10} = \bar{T}$. When tartar-emetic dried at 212° is exposed to a stronger heat, it loses water, and there remains in the salt an acid, the formula of which must be $C_8H_2O_8$; but when this salt is redissolved in water, the original acid is reproduced. (Liebig.)

Tartaric acid occurs chiefly in the juice of the grape, but also in many other fruits and parts of vegetables. It was discovered by Scheele, in 1770. It is extracted from the tartar of the grape, which is monobasic tartrate of potash, $\bar{T}, KO, HO$, by a process similar to that employed for citric acid, namely, converting it into tartrate of lime, and decomposing this salt by sulphuric acid. It is prepared in large quantity for the calico printers, and for medical use, and is sold in a state of purity at a very low price. Its medical use is the same as that of citric acid. It cannot be easily prepared in the laboratory on a small scale; but a process is given in the Pharmacopœiæ for making it. Tartaric acid forms large transparent, oblique, rhombic prisms, which have a pleasant sour taste. The aqueous solution becomes mouldy by keeping: the solution in alcohol, when heated, is converted into monobasic tartrate of oxide of ethule. When heated, it melts, and yields a variety of new and interesting products.

It contains the elements of 1 at. hydrated acetic acid, and 2 at. hydrated oxalic acid; or of 2 at. hydrated formic acid, and 1 at. anhydrous malic acid. When heated with caustic alkalies, it is resolved into acetic and oxalic acids. (Gay-Lussac.) With hyperoxides it yields formic acid, carbonic acid, and tartrate of protoxide: with diluted sulphuric acid it yields a large quantity of formic acid.

A solution of tartaric acid causes with solutions of caustic lime, baryta, and strontia, white precipitates soluble in excess of acid. It does not precipitate the salts of these earths. It is used as a test for potash and its salts, in which it produces the sparingly soluble monobasic tartrate of potash (cream of tartar). The presence of tartaric acid in the solutions of many metallic oxides prevents their precipitation by alkalies.

TARTRATES.

Tartaric acid forms with bases monobasic and bibasic salts. The former are acid, and have the formula $\bar{T},MO,HO$: the latter are neutral, and their formula is $\bar{T},2MO$. These two eq. of metallic oxides may be different: hence a series of salts with two bases, $\bar{T},\left.\begin{matrix}MO\\mO\end{matrix}\right\}$. With potash and oxide of antimony, tartaric acid forms an important series of compounds. Tartar-emetic contains, for 1 eq. tartaric acid, 1 at. = 3 eq. sesquioxide of antimony, and 1 eq. of potash; it must therefore be viewed as a salt with excess of base. The neutral salt has been lately described. As already mentioned, tartar-emetic at 392°, without blackening, gives off 2 at. water, formed either at the expense of the acid, or by part of the oxygen of the sesquioxide, with hydrogen from the acid. In the latter case it must contain either metallic antimony or a suboxide; but, at all events, it no longer belongs, in this state, to the regular series of the tartrates. When put into water, however, tartar-emetic is reproduced. (Liebig.) At 570° all the tartrates are blackened, and yield a peculiar smell, which is characteristic of this family of salts.

The soluble neutral tartrates become insoluble or sparingly soluble by the addition of tartaric acid; the insoluble or sparingly soluble are rendered soluble by such addition. The tartrates insoluble in water are distinguished by their easy and complete solubility in caustic potash or ammonia.

The tartrates are among the most interesting of organic salts. Our knowledge of them, however, is very far from complete, and a careful study of them will certainly lead to very important results in regard to the true theory of all such combinations.

Tartrate of Ammonia.—*a.* Neutral or bibasic. $\bar{T},2AdH_2O + 2aq.$ (Dulk.) This salt is crystallizable. Its solution, when evaporated, loses ammonia and yields the acid salt. *b.* Acid or monobasic. $\bar{T},AdH_2O,aq.$ (Dulk.) This is a crystalline powder, very soluble in hot, sparingly soluble in cold water. It corresponds to cream of tartar.

Tartrate of Oxide of Ethule. — The neutral or bibasic salt is not yet known. The acid salt, $\bar{T},AeO,aq.$ (Guèrin Varry), is produced by heating tartaric acid with alcohol; and may be obtained pure by decomposing the double tartrate of baryta and ethule with sulphuric acid, and evaporating the filtered solution in vacuo. It crystallizes in elongated rhombic prisms, and is very soluble in water and alcohol, insoluble in ether. It is decomposed by heat, with the usual smell of the tartrates. This compound was formerly called tartrovinic acid; it forms with bases double salts, formerly called tartrovinates. It dissolves zinc and iron with disengagement of hydrogen.

Tartrate of Ammonia and Ethule.—$\bar{T},AeO,AdH_2O.$—This salt forms a shining, silky, crystalline and fibrous mass. (Guérin Varry.)

Tartrate of Oxide of Methule.—The acid salt, $\bar{T},MeO,aq.$ is formed in the same way as the tartrovinic acid. It crystallizes in fine needles, and forms a series of double salts. (Guérin Varry.)

Tartrate of Potash.—*a.* Acid or monobasic. Syn. Tartar; Cream of Tartar; Bitartrate of potash. Formula, $\bar{T},KO,HO.$—This important salt occurs in many vegetable juices, but in largest quantity in the juice of the grape; from which it separates in a more or less coloured crystalline crust, as soon as the sugar by fermentation has been converted into alcohol, in which it is insoluble. It is purified by recrystallization, when it forms, on cooling, a crust on the surface of the liquid: hence the name *Cremor tartari.*

It forms hard, opaque, oblique, rhombic prisms, or irregular six-sided prisms. It feels gritty between the teeth, has a faint acid taste, and is permanent in the air. When heated, it melts, froths, gives out the peculiar smell of the heated tartrates, and yields by distillation a solid acid, one of the pyrogenous tartaric acids. It is soluble in 18 parts of boiling water, and in 184 parts at 70°. From its insolubility, it is always formed when an excess of tartaric acid is brought into contact with a salt of potash. Stirring with a glass rod, and the addition of alcohol, hasten its separation. Potash may thus be detected and distinguished from soda.

The purest carbonate of potash (salt of tartar) is obtained by igniting cream of tartar. The residue is the well-known *black flux*, a mixture of charcoal with carbonate of potash; from which water dissolves the carbonate. If made with raw tartar, which contains nitrogen, it is contaminated by cyanide of potassium. When 2 parts of nitre and 1 of tartar are ignited, *white flux* is left, which is nothing else than carbonate of potash; all the charcoal having been oxidized by the nitric acid. Tartar always contains a little tartrate of lime.

Cream of tartar is much used in dyeing, from its power of dissolving metallic oxides. In medicine it is very often used as a laxative and diuretic, and to form an acidulous drink in febrile diseases.

b. Neutral or bibasic.—This salt, the soluble tartar of the pharmacopœia, $\bar{T},2KO$, is easily obtained by adding cream of tartar to a hot solution of carbonate of potash till all effervescence ceases, and the liquid is quite neutral. It forms transparent right rhombic prisms, and has a mild saline, somewhat bitter taste. It is used as a laxative.

Tartrate of Potash and Ammonia.—Syn. Ammoniated Tartar. Formula, $\bar{T},KO,AdH_2O, + aq$. It is formed by neutralizing cream of tartar with ammonia, and crystallizing the solution. It forms right rhombic prisms, large and transparent; and has a cooling, pungent, saline taste. It is very soluble in water; and the solution when heated loses ammonia, and deposits cream of tartar. It is decomposed by acids in the same way, tartar being deposited. This salt is used in medicine as a laxative, especially on the continent.

Tartrate of Potash and Ethule.—$\bar{T},KO,AeO, + aq$. (Guérin Varry.) Obtained by adding a slight excess of sulphate of potash to the double salt of baryta and ethule, and evaporating the filtered solution. It crystallizes in the same form as the preceding salt, being isomorphous with it. Its solution, when heated, is resolved into cream of tartar and alcohol. Guérin Varry mentions another compound of the same ingredients, which has an alkaline reaction, and crystallizes in eight-sided prisms. Its composition is unknown.

Tartrate of Potash and Methule.—$\bar{T},KO,MeO + aq$. (Guérin Varry.) A crystallizable salt, analogous in its mode of formation and in its properties to the foregoing.

Tartrate of Potash and Boracic Acid.—$\bar{T},KO,BO_3$. (Duflos.) Syn. Soluble Tartar of the French Pharmacopœia. Cream of tartar and boracic acid, in the proportion of their equivalents, are kept in contact with warm water till all is dissolved, and the liquid then evaporated to dryness. It forms a white amorphous mass, of a sour taste, very soluble in water, insoluble in alcohol. Soubeiran recommends 4 parts of tartar to 1 of boracic acid, which yields $3\bar{T} + 3KO + BO_3$. The salt of Duflos is exactly analogous to tartar-emetic; that of Soubeiran to the neutral tartrate of potash and antimony lately discovered. The first salt dissolves a large quantity of cream of tartar, which by evaporation it deposits in crystals. (Duflos.) The solution must not be boiled, otherwise some boracic acid is dissipated. This compound is used as a laxative on the Continent.

Tartrate of Potash and Arsenious Acid.—According to Mitscherlich, this compound may be formed, and is analogous in form and composition to tartar-emetic. Probable formula, $\bar{T},KO,As_2O_3$. The mode of preparing it has not been described.

Tartrate of Soda.—*a.* Acid or monobasic. $\bar{T},NaO,HO+2aq$. (Bucholz.) Formed by adding tartaric acid to the neutral salt. Six-sided prisms, very sour to the taste, very soluble in water. It is used to prepare chlorate of soda from chlorate of potash. When mixed with the latter, eq. to eq., cream of tartar and chlorate of soda are produced—*b.* Neutral or bibasic. $\bar{T},2NaO, + 4aq$.

Formed by neutralizing tartaric acid with soda. Transparent prisms, permanent in the air, very soluble.

Seidlitz Powders, or Carbonated Effervescing Cheltenham Salts, are an intimate mixture of equal parts of tartaric acid and bicarbonate of soda, in atomic proportions. To these is often added a portion of sulphate of magnesia, or of the tartrate of potash and soda (Rochelle Salt). The powders must be well dried; otherwise they slowly act on each other, and lose the effervescing quality.

Tartrate of Soda and Ethule.—$\bar{T},NaO,AeO, + 2aq.$ (Guérin Varry.) White rhomboidal tables.

Tartrate of Potash and Soda.—$\bar{T},KO,NaO + 10aq.$ (Schulze.) Syn. Rochelle Salt; Salt of Seignette. Formed by neutralizing carbonate of soda with cream of tartar. It forms very large transparent right rhombic, or six, eight, and ten-sided prisms. It has a very mild, hardly saline taste; and may be given in soup or beef-tea in a sufficient dose, without the knowledge of the patient, from its comparative tastelessness. It acts as a laxative, like neutral salts in general.

This salt forms with the tartrate of potash and boracic acid of Duflos a double salt $(\bar{T},KO,NaO) + (\bar{T},KO,BO_3)$. (Duflos.) Syn. Boracic Tartar; Tartarized Borax. One part of borax (biborate of soda) and 3 of cream of tartar are dissolved in 20 of water. The clear portion is evaporated to dryness, and yields a gummy mass, of an acidulous saline taste, deliquescing in the air. The powder, if not very long and carefully dried, and stirred in the drying, has the inconvenience of caking in the bottles in which it is kept, so that it cannot be extracted without breaking them. It is much used in medicine on the Continent.

Tartrate of Lithia.—*a.* Monobasic, $\bar{T},LO,HO + 3aq.$ (Dulk.) *b.* Bibasic, $\bar{T},2LO.$ (Dulk.) The former is crystallizable and very soluble; the latter forms a crystalline mass. Tartrate of lithia and potash, $\bar{T},KO,LO, + 2aq.$ and of lithia and soda, $\bar{T},NaO,LO + 4aq.$ are both soluble and crystallizable. (Dulk.)

Tartrate of Baryta.—$\bar{T},2BaO, + 2aq.$ (Dulk.) A white powder, insoluble in water, soluble in tartaric acid.

Tartrate of Baryta and Ethule.—$\bar{T},BaO,AeO, + 2aq.$ (Guérin Varry.) A solution of tartaric acid in alcohol is first heated, then mixed with water, and neutralized with carbonate of baryta. The filtered liquid yields, by spontaneous evaporation, crystals of this salt, which are soluble in water.

Tartrate of Baryta and Methule.—$\bar{T}$,BaO,MeO,+aq. (Dumas and Péligot.) Analogous to the foregoing salt. It is very soluble in water and crystallizable.

Tartrate of Baryta and Potash, $\bar{T}$,BaO,KO,+2aq. and *Tartrate of Baryta and Soda,* $\bar{T}$,BaO,NaO + 2aq. are both sparingly soluble crystalline powders. (Dulk.)

Tartrate of Strontia. —$\bar{T}$,2SrO + 8aq. (Dulk.) Small four-sided tabular crystals, which lose all their water by a gentle heat or in vacuo.

With strontia, tartaric acid forms a series of double salts, analogous to those above described with baryta.

Tartrate of Lime.—$\bar{T}$,2CaO. This salt, which is formed by neutralizing with the atomic proportion of chalk a boiling solution of cream of tartar, is a white insoluble powder. The filtered liquid, which contains half the tartaric acid in the form of neutral tartrate of potash, yields a quantity of tartrate of lime equal to the first, by the addition of an atom of chloride of calcium. It is from this salt that all the tartaric acid of commerce is obtained, as formerly mentioned.

Of the remaining tartrates, the most important are those of antimony and potash, and of iron and potash, both of which are used in medicine. These will be described; but, in regard to the numerous tartrates and double tartrates which might be enumerated, the salts already described will give a sufficiently clear idea of their constitution, while we cannot here afford space for a detailed account of them.

Tartrate of Potash and Sesquioxide of Antimony.—*a.* With excess of base. Formula, $\bar{T},Ko,Sb_2O_3 + 2aq$. Syn. Tartar-emetic; Tartarized Antimony. This very important compound is prepared by boiling cream of tartar and finely powdered sesquioxide of antimony, in atomic proportions, with water till all is dissolved. The solution when evaporated deposits octohedral crystals of tartar-emetic. Minute directions for its preparation are given in the Pharmacopœiæ and Dispensatories. Its uses in medicine as an emetic, purgative, diaphoretic, sedative, febrifuge, and counter-irritant, are so well known and important, that it may be truly said that no mineral remedy, except perhaps calomel, is more useful to the practitioner.

When heated to 212°, the crystals become anhydrous. Their formula then is $C_8H_4O_{10},KO,Sb_2O_3$. But, when heated to 480°, they give off, as already mentioned, 2 at. of water, the elements of which must be derived either from the acid alone, or from the sesquioxide and acid together. Their formula then is $C_8H_2O_8$, KO,Sb_2O_3, or $C_8H_2O_{10},KO,Sb_2O$; or they may contain antimony in the metallic state. It might be supposed that tartaric acid, as it exists in tartrate of silver and tartar-emetic at 212°, $C_8H_4O_{10}$, contains 2 at. of water ready formed, and that the anhydrous acid is really $C_8H_2O_8$. In favour of this view might be adduced the fact that tartar-emetic heated to 480°, when dissolved in water, is restored to its original composition. But not only is it contrary to all analogy to suppose the existence of water ready formed in a salt of silver heated to 212°, such salts being without exception anhydrous; but, moreover, this assumption would lead to many other most improbable conclusions. For the present, therefore, we must consider the tartaric acid, anhydrous, to be $C_8H_4O_{10}$; and we must ascribe the appearance of the 2 at. of water when dry tartar-emetic is heated to 480°, to a partial reduction of the oxide of antimony by the hydrogen of the acid. Liebig considers that a part of the antimony is actually reduced to the metallic state; as above explained, it seems to me possible that a dinoxide may be formed, Sb_2O, which must then be combined with an acid, the formula of which will be $C_8H_2O_{10}$. Such a dinoxide of antimony, however, is unknown. In every view the change produced on tartar-emetic at 480° is most interesting. It occurs in no other salt save tartar-emetic, and hence must be owing to the presence in that salt of an oxide containing 2 at. oxygen more than the usual bases (protoxides). Possibly the same change may occur in the compounds of cream of tartar with boracic acid, arsenious acid, and peroxide of iron; all of which, like sesquioxide of antimony, contain 3 at. oxygen. For a full discussion of this subject I refer to Liebig's paper. (Ann. der Pharm. xxvi. 113.)

b. Neutral Tartrate of Antimony and Potash.—This salt, $3\overline{T},3KO,Sb_2O_3$, is found in the mother-liquid of the crystallization of tartar-emetic, especially where an excess of cream of tartar has been used. It forms small crystals grouped together, but crystallizes with difficulty. By boiling its solution with sesquioxide of antimony, it may be entirely crystallized as tartar-emetic. Hence the importance of having a slight excess of oxide of antimony in the preparation of tartar-emetic. Other salts of tartaric acid, antimony, and potash are found in the same mother-liquid, the nature of which is not yet sufficiently known.

Tartrate of Potash and Sesquioxide of Iron (peroxide of iron).—Syn. Tartarized Iron. This salt is formed, according to the Pharmacopœiæ, by exposing for a long time to the air a mixture of cream of tartar and iron filings moistened with water. A soluble brown compound is gradually formed, the iron absorbing oxygen from the atmosphere. The solution, when evaporated, leaves an amorphous gummy mass, which dissolves readily in water. It might probably be easily formed by digesting cream of tartar with hydrated peroxide of iron. Its probable formula is $\bar{T},KO,Fe_2O_3$: but a neutral compound probably exists, $3\bar{T},3KO,Fe_2O_3$. The tartarized iron is used in medicine.

Tartrate of Lead.—A white insoluble powder, which, when heated in close vessels, leaves a mixture of carbon and metallic lead in a state of minute division, which takes fire spontaneously when exposed to the air. Formula, $\bar{T},2PbO$.

Tartrate of Silver.—$\bar{T},2AgO$. This salt is soluble in hot water, and on cooling crystallizes in silvery scales.

ACTION OF HEAT ON TARTARIC ACID.

This subject has been most ably and minutely investigated by Fremy. (Ann. der Pharm. xxix. 142.) When tartaric acid is heated, with certain precautions, it melts, and gives off one-fourth of its water. It is now deliquescent, and forms soluble salts with lime and baryta, by which means it may be purified from tartaric acid. This new acid, to which Fremy has given the name of *Tartralic Acid*, has, in its salts, the same composition as tartaric acid, but neutralizes one-fourth less base. It differs from tartaric acid, therefore, as pyrophosphoric acid differs from phosphoric acid. The general formula of its salts is, $C_8H_4O_{10} + 1\frac{1}{2}MO$; or, more correctly, $C_{16}H_8O_{20} + 3MO$.

Tartralate of Lime.—$C_{16}H_8O_{20},3CaO + 3aq$. The solution of this salt undergoes spontaneous decomposition, yielding tartrate of lime and free tartaric acid. Thus, 2 at. tartralate of lime, $2(C_{16}H_8O_{20},3CaO + 3aq.)$ yield 3 at. tartrate of lime, $3(C_8H_4O_{10},2CaO, + 2aq.)$ and 1 at. tartaric acid, $C_8H_4O_{10}$, which takes up 2 at. water from the liquid.

The tartralate of baryta is analogous to that of lime. Tartralate of lead is anhydrous, $C_{16}H_8O_{20},3PbO$.

When tartralic acid is still further heated, it loses more water, and is converted into tartrelic acid, $C_8H_4O_{10} + HO$: this is still the composition of tartaric acid, but with only half the neutralizing power. It corresponds to metaphosphoric acid. Its salts have the general formula, $C_8H_4O_{10},MO$.

The tartrelates of lead, baryta, and lime are anhydrous. In contact with water, the tartrelic acid, as well as the tartralic, passes into tartaric acid, just as happens with the modified phosphoric acids. The tartrelates also, in contact with water, yield tartrates and free tartaric acid; for 2 at. tartrelate of a protoxide, $2(C_8H_4O_{10},MO)$ give 1 at. tartrate, $C_8H_4O_{10},2MO$, and 1 at. tartaric acid, $C_8H_4O_{10}$, which takes 2 at. water from the liquid.

When the heat is raised still further, tartaric, tartralic, and tartrelic acids all lose the whole of their water, and leave anhydrous tartaric acid, $C_8H_4O_{10}$. This is the first instance of an organic acid in the anhydrous state; but it has lost all acid properties, and is quite insoluble in water. This is a powerful argument in favour of the view, according to which all acids are compounds of hydrogen. This inert, insoluble anhydrous tartaric acid, when left long in contact with water, takes up the elements of that fluid by degrees, and passes through the stages of tartrelic and tartralic acids into tartaric acid. According to the hypothesis just alluded to, tartrelic acid will be $C_8H_4O_{11} + H$; tartralic acid, $C_{16}H_8O_{23} + H_3$; and tartaric acid, $C_8H_4O_{12} + H_2$.

By a still higher temperature tartaric acid is decomposed, yielding carbonic acid, water, and two pyrogenous acids, one of which is crystalline, the other oily. The crystalline acid is $C_5H_3O_3 +$ aq. (Pelouze): the oily acid is $C_6H_3O_5 +$ aq. (Berzelius). They are formed from 2 at. tartrelic acid, according to the following equation:

$$2(C_8H_4O_{10},HO)=(C_5H_3O_3,HO)+(C_6H_3O_5,HO)+5CO_2+2HO.$$

For details concerning these acids, I must refer to the original memoirs in the foreign journals.

RACEMIC ACID.

Syn. Paratartaric Acid; Acid of the Vosges. Formula, $C_8H_4O_{10} + 2HO$. Symb. $\bar{R}$. This remarkable acid, which in its parallelism with tartaric acid, affords the most complete and curious example of isomerism, is found in the juice of the grape, particularly in the district of the Vosges, replacing the ordinary tartaric acid. Its composition, as far as our present knowledge extends, is not only the same in 100 parts as that of tartaric acid; but its atomic weight, derived from the analyses of its salts, appears to be exactly the same. Moreover, its salts, although quite distinct from those of tartaric acid, are singularly analogous to them. It cannot be doubted, however, that there must be a real difference in the constitution of these acids, and that this will be discovered as soon as the salts of both acids have been submitted to a minute and thorough investigation. There is nothing yet known, for example, inconsistent with the supposition that racemic acid may be an acid requiring 4 atoms of base to form neutral salts, in which case its formula would be $C_{16}H_8O_{20} + 4HO$.

The crystallized racemic acid contains more water than crystallized tartaric acid. Its formula is $C_8H_4O_{10},2HO + 2aq$. The two atoms of water of crystallization are expelled by a heat of about 300°, and the remaining acid has the composition of crystallized tartaric acid. It might be supposed to be anhydrous, and therefore to differ in composition from tartaric acid, were it not that, in combining with bases, with oxide of silver for example, it loses the two atoms of water remaining, which are replaced by metallic oxide.

The action of heat on racemic acid has been studied by Fremy and Berzelius. The former has shown that it yields three compounds, corresponding to those from tartaric acid, and quite analogous to them. These he calls paratartralic, paratartrelic, and anhydrous racemic acid; the composition of which is the same as that of the corresponding products from tartaric acid. Berzelius has found that racemic acid, when distilled, yields the same products as tartaric acid, namely, carbonic acid, water, and the two pyrotartaric acids formerly described.

With potash and sesquioxide of antimony, racemic acid yields a tartar-emetic, distinct in properties from that made with tartaric acid, but identical with it in composition; $\bar{R},KO,Sb_2O_3$. This salt, when heated to 480° or 500°, undergoes the same curious change as tartar-emetic, giving off 2 at. of water.

The action of racemic acid on alcohol corresponds to that of tartaric acid; and in general its tendency to form salts with two different bases is the same as that of tartaric acid.

These two acids are distinguished by the more sparing solubility of racemic acid, by the force with which it retains its combined water, and by the crystalline form of their salts, which frequently differ in the amount of water of crystallization.

MALIC ACID.

Formula, $C_8H_4O_8 + 2HO$. (Liebig.) Symb. $\bar{M}$. A bibasic acid. This acid is found in many fruits, particularly in the apple. It is most easily obtained from the fruit of sorbus aucuparia (mountain ash or rowan tree) immediately after it has turned red, but while still unripe. The juice is heated to coagulate some albuminous matter, and filtered. It is then nearly neutralized with ammonia, and to 72 parts of juice a solution of 1 part of acetate of lead is added. This causes a precipitate of tartrate and citrate of lead. The filtered liquid is now precipitated by nitrate of lead, and the precipitate allowed to stand in the liquid till it has changed into a mass of crystals. This is well washed, dried, powdered, suspended in water, and decomposed by a current of sulphuretted hydrogen. The filtered liquid is neutralized with ammonia, and decolorized by digestion with animal charcoal. The colourless malate of ammonia is again precipitated by nitrate of lead, and the malate of lead decomposed by sulphuretted hydrogen. By this process Winkler obtained from 296 ounces of juice 19 ounces of pure malate of lead, or upwards of 6 ounces of crystallized malic acid. Liebig recommends converting the first impure solution of the acid into acid malate of ammonia by neutralizing one half, and mixing it with the other. This salt forms large crystals, and is easily obtained colourless.

Malic acid is exceedingly soluble in water, and crystallizes with more difficulty than the foregoing acids. It has a very pleasant acid taste. When exposed to heat, it yields two pyrogenous acids, called by Pelouze, who examined them, maleic and paramaleic acids. They are isomeric, and appear to be identical with two acids found in the vegetable kingdom, namely, equisetic (aconitic ?) acid, and fumaric acid.

MALATES.

Malic acid, like tartaric acid, forms neutral or bibasic salts, acid or monobasic salts, and a third class, which are neutral and bibasic, but contain two different bases.

Malate of Ammonia.—The acid or monobasic salt has been described by Liebig. It forms large transparent crystals, resembling white sugar-candy. It is used in the preparation of pure malic acid and malates. Formula, $\bar{M},AdH_2O,HO$.

Malate of Lime.—*a.* Bibasic. This salt is formed when malic acid is neutralized by lime water. It is soluble in water when formed, and continues so if dried at the ordinary temperature. Formula, $\overline{M},2CaO + 2aq$. If its solution be boiled, the salt loses 1 at. of water, and becomes $\overline{M},2CaO + aq.$, which is an insoluble salt. The last atom of water is expelled by a heat of nearly 400°, and the anhydrous salt is left, $\overline{M},2CaO$. (Richardson and Merzdorf.)—*b.* Monobasic. This salt is obtained by digesting, in the cold, malic acid with chalk, and gently evaporating the solution, when the acid malate crystallizes. When heated to 390°, it is $\overline{M},CaO,HO$. If heated only to 212°, it is $\overline{M},CaO,HO + 4aq$. If dried at the ordinary temperature, $\overline{M},CaO,HO + 8aq$.

Malate of Baryta.—When a solution of carbonate of baryta is evaporated in vacuo, it yields soluble crystals which are hydrated bibasic malate of baryta, $\overline{M},2BaO + 2aq$. If evaporated at a higher temperature, it deposits a crystalline powder, almost insoluble, which is the anhydrous salt, $\overline{M},2BaO$.

Malate of Lead.—The malic acid has a great tendency to form with lead the monobasic or acid salt. This was first obtained by Donovan, who thought that it contained a new acid, sorbic acid. It forms shining silvery scales. Formula, $\overline{M},PbO,HO$.

Malate of Copper.—According to Richardson and Merzdorf, this salt is a bibasic salt with excess of base. It occurs in three forms: $\overline{M},2CuO,CuO + 6aq.$; $\overline{M},2CuO,CuO + 5aq.$; and $\overline{M},2CuO,CuO + 4aq$. The two former are soluble in water: when their solutions are heated, the latter salt is deposited, which is insoluble.

The malates in general are little known, and require a minute investigation. The composition of the malate of copper differs remarkably from that of the other salts, and renders it probable that the true constitution of malic acid is yet unknown.

ACTION OF HEAT ON MALIC ACID.

When crystallized malic acid is kept for a long time at a temperature a little higher than its melting point, it loses water, and is entirely converted into fumaric or paramaleic acid. But if it be distilled by a very quick fire, it yields a volatile product, which is equisetic or maleic acid, while fumaric acid remains in the retort. These two acids have different properties, but the same composition, in 100 parts, but differ in atomic weight, one being bibasic, and the other monobasic.

MALEIC ACID.

A bibasic acid. Formula, $C_8H_2O_6 + 2HO$. Symbol, $\overline{Ma}$. When malic acid is distilled with a quick fire, maleic acid passes over with water, in which it is dissolved, and from which it is separated in crystals by evaporation. The crystals are plates, or oblique rhombic prisms, very soluble in water, alcohol, and ether. These solutions have a taste at first sour, afterwards nauseous and metallic. It is distinguished from aconitic acid, which has the same composition, by the action of heat, which resolves it into water and anhydrous maleic acid. If kept for a long time melted at a lower temperature, it gradually passes, like malic acid, into a crystalline mass of fumaric acid. Maleic acid differs from malic acid in containing 2 at. of water less, which sufficiently explains its formation. It was formerly supposed to be identical with equisetic or aconitic acid; but, from the recent researches of Liebig, maleic acid appears to be decidedly bibasic.

The salts of maleic acid are insoluble, or sparingly soluble. The maleate of lead is $\overline{Ma},2PbO + 6aq$. (Pelouze.) There are two maleates of silver: neutral and acid. The former is $\overline{Ma},2AgO$; the latter $\overline{Ma}, \left.\begin{matrix}AgO\\HO\end{matrix}\right\}$ (Liebig.)

FUMARIC ACID.

A monobasic acid. Formula, $C_4HO_3 + HO$. Symb. $\overline{Fu}$. Discovered as a product of the action of heat on malic acid by Lassaigne, and analyzed by Pelouze; in the Fumaria officinalis by Winkler, and in Iceland moss by Schoedler. Demarçay first proved the identity of the acid of the fumaria with that derived from malic acid.

It is best obtained by keeping malic acid for a long time heated a few degrees beyond its melting point, when the liquid is gradually converted into a crystalline mass, from which cold water removes any unchanged malic acid. It is also obtained by heating maleic acid in the same way; and some salts of malic acid, when heated, are converted into salts of fumaric acid.

From the juice of Fumaria officinalis it is precipitated as fumarate of lead by the addition of acetate of lead. The same salt may be obtained from Iceland moss by digesting it with milk of lime, and adding acetate of lead to the filtered solution. The fumarate of lead is then suspended in water, and decomposed by sulphuretted hydrogen. The impure crystals first obtained are purified by solution in hot nitric acid, which on cooling deposits the fumaric acid pure and colourless.

Fumaric acid forms fine soft micaceous scales, soluble in 200 parts of cold water, more soluble in hot water and in alcohol. When heated a small portion sublimes, but the greater part is decomposed.

Fumaramide.—$C_4HO_2 + Ad.$ (Hagen.) Formed by the action of aqua ammoniæ on fumarate of oxide of ethule. A snow-white powder, which is slowly dissolved by long boiling in water. By acids and alkalies it is resolved, like other amides, the elements of water being assimilated, into ammonia and the acid.

The salts of fumaric acid are for the most part crystallizable. It forms with ammonia an acid salt in long prisms, $2\overline{Fu},AdH_2O,HO$. Its salts with the oxides of lead and silver have exactly the same composition in 100 parts as the corresponding salts of maleic acid. Their formulæ are C_4HO_3,PbO, and C_4HO_3,AgO.

ACIDS OF UNKNOWN CONSTITUTION.

The acids now to be described are those whose composition is known, but in regard to which it is uncertain whether they are to be considered as monobasic or polybasic.

KINIC ACID.

Formula of the acid in the basic kinate of lead .	$C_7H_4O_4$
,, ,, in the basic kinate of copper	$C_7H_5O_5$
,, of the crystallized acid . . .	$C_7H_6O_6$

Kinic acid was discovered in cinchona bark by Hoffmann in 1790. It has since been studied by Henry and Plisson, Baup, Liebig, and Woskresensky, the latter of whom ascertained its true composition.

It is obtained from kinate of lime (a salt which occurs in the manufacture of sulphate of quinine) by the action of diluted sulphuric acid. The sulphate of lime being separated by filtration, the filtered liquid is evaporated to the consistence of syrup, and set aside, when it gradually deposits large crystals of kinic acid, which are oblique rhombic prisms, very similar in appearance to tartaric acid. They are permanent in the air, soluble in 2 parts of water, also in alcohol. Pelletier and Caventon obtained by the distillation of kinic acid a volatile crystalline acid, distinguished by the property of causing a fine green precipitate in salts of peroxide of iron. This acid has not been further examined.

SALTS OF KINIC ACID.

Kinic acid differs from all other organic acids in its relation to bases. According to Woskresensky, it forms four series of salts. In one of its compounds with oxide of lead, 2 at. of basic water are replaced by 2 at. of oxide of lead. This would give for the salt $C_7H_4O_4 + 2PbO$; and for the acid $C_7H_4O_4 + 2HO$. But in the salt called basic kinate of copper, the formula is $C_7H_4O_4 + \left.\begin{matrix}CuO\\HO\end{matrix}\right\}$. Again, the kinate of lime, dried at 248°, contains for 1 eq. of lime a quantity of acid represented by $C_{14}H_{11}O_{11}$; and the kinate of silver is also $C_{14}H_{11}O_{11},AgO$. It is possible that in combining with a larger proportion of the oxides of lead and copper than is equivalent to the base in the salts of lime and silver, the acid has undergone a modification analogous to that which occurs in metaphosphoric or pyrophosphoric acids when they are ignited with excess of base. All the kinates, except that of lead, are soluble. When we compare kinic acid with gallic acid $C_7H_3O_5$, we find that the number of equivalents is the same, but that gallic acid contains 1 eq. of oxygen less, and 1 eq. of hydrogen more. Both acids, according to Berzelius, occur in the bark and soft wood of many trees. *Kinate of lime* occurs ready formed in all kinds of cinchona bark; and when the acidulated infusion is precipitated with excess of lime to obtain quinine or cinchonine, the kinate of lime remains dissolved, and crystallizes when the solution is concentrated to a syrup and set aside.

The other kinates are little known, and the anomalies in their composition have been mentioned above.

PRODUCTS OF THE DECOMPOSITION OF KINIC ACID.

Kinoyle.—When a kinate is distilled, there is obtained, along with the vapour of water, a sublimate in golden-yellow needles. It is obtained easily by heating kinic acid with peroxide of manganese and sulphuric acid. This substance is Kinoyle. It is accompanied by formic acid and other products. (Woskresensky.)

Kinoyle is volatile, and distils unchanged in close vessels. In water it is sparingly soluble; but very soluble in alcohol and ether. Its composition is unknown.

VOLATILE ACIDS OF BUTTER.

In the butter of the cow and goat three volatile acids occur in small quantity, besides the fatty matter which constitutes the chief part of the butter. Chevreul, who discovered these acids, has named them Butyric, Capric, and Caproic acids.

When butter is saponified by boiling with caustic alkalies, and the resulting soap is decomposed by an excess of tartaric acid, certain fatty acids, insoluble in water, are separated. The water retains in solution the tartrate of the alkali, oxide of glycerule, and the volatile acids now under consideration. The solution when distilled yields a product containing the three acids. It is neutralized by hydrate of baryta, and evaporated. The first crystals which are deposited are caprate of baryta; those which crystallize last of all are butyrate of baryta. The intermediate portions are principally caproate of baryta. Butyrate of baryta is soluble in $2\frac{3}{4}$ parts, caproate of baryta in $12\frac{1}{2}$ parts, and caprate of baryta in 200 parts of water. Hence by careful management these three salts may be separated and purified. (Chevreul.)

Hydrated butyric acid is soluble in water in all proportions. The other acids are sparingly soluble, and appear as oils when their salts are decomposed by stronger acids.

BUTYRIC ACID.

Formula of the anhydrous acid . . . $C_8H_5O_3$? (Chevreul.)
,, ,, hydrated acid . . . $C_8H_5O_3+HO$?

Butyrate of baryta is dissolved in water, and the solution decomposed by sulphuric acid, care being taken to leave a little of the salt undecomposed. The filtered liquid when distilled yields a solution of pure butyric acid, from which the water is removed by chloride of calcium. The dried butyric acid appears as a clear oily liquid, with an acid smell of rancid butter, and a pungent acid taste. Sp. g. 0·9765 at 77°. It continues liquid at 16°, evaporates in the air, and boils above 212°.

SALTS OF BUTYRIC ACID.

All the butyrates have a slight smell of the acid. The butyrate of oxide of ethule, however, has a penetrating ethereal smell, like that of old cheese. It is obtained by distilling hydrated butyric acid with alcohol and a little sulphuric acid. (Simon.) It is employed to give to potatoe and grain spirits a flavour like that of rum. Butyrate of oxide of glycerule is an ingredient, in small quantity, of butter. The butyrates of baryta, lime, and lead, are soluble in water, and crystallizable.

According to Löwig, the butyric acid in the dry salt of baryta is $C_7H_6O_3$; and when the salt is distilled, carbonate of baryta is left, and a volatile liquid passes over, which he calls butyrone, and which is $C_6H_6O = C_7H_6O_3 - CO_2$. (Kraus.) ? The composition of this acid cannot be considered as determined.

CAPROIC ACID.

It is obtained from the salt of baryta by adding sulphuric acid to its solution, when the caproic acid rises to the surface as an oil, which is dried by chloride of calcium. It is a clear oily liquid, having a sour smell like that of sweat, and a taste at first pungent, afterwards sweetish, like that of apples. Sp. g. 0·922. Liquid at 16°; evaporates in the air; boils at a temperature higher than 212°. It is soluble in 96 parts of water, and miscible with alcohol, ether, and oils. Chevreul's analysis would indicate the formula $C_{12}H_9O_3$ for the anhydrous acid.

The salts of caproic acid are soluble in water, and have the smell of the acid. The caproate of oxide of glycerule exists in butter.

CAPRIC ACID.

Formula of the acid in the caprate of lead, $C_{18}H_{14}O_3$. (Chevreul.) It is obtained from the salt of baryta in the same way as the preceding acid. At 65° it resembles the caproic acid; but at 44° it crystallizes when shaken in fine needles, which remain solid at 60°, and melt entirely when warmed beyond that point. It has a smell like that of caproic acid, but more like that of the goat. It is soluble in water and alcohol.

The caprate of baryta is crystallizable, and requires 200 parts of water for its solution. When a solution of this salt is kept in a stoppered bottle, carbonate of baryta is deposited, and the liquid acquires the smell of the cheese of Roquefort.

Regarding as radical for capric and caproic acid the hyduret of carbon $C_{24}H_{18}$, the numbers from the analysis of caproic acid
corresponds to . . . . . . $C_{24}H_{18}+O_6$
capric acid . . . . $C_{24}H_{18}+O_4$.

HIRCIC ACID.

Composition unknown. Discovered by Chevreul in the fat of the goat. It is prepared from the fat just as the three preceding acids are from butter, and resembles them in appearance, being an oily liquid with an offensive smell of goats.

PHOCENIC ACID.

Syn. Delphinic acid. (Chevreul.)

Formula of the acid in the phocenate of lead $C_{10}H_7O_3$.
„ of the hydrated acid . . . . . . $C_{10}H_7O_3+HO$.

Discovered by Chevreul in train oil, and in the berries of Viburnum opulus. It is prepared from whale or seal oil exactly in the same way as the volatile acids from butter. It forms, when pure, a mobile oily fluid, which has a strong acid smell of train oil and rancid butter, and a pungent acid taste. It is very similar to the preceding acids. It dissolves in 18 parts of water; and the solution, when kept, undergoes decomposition, acquiring the smell of greased leather. Like the preceding acids it is volatile.

The salts of phocenic acid are soluble and crystallizable. Phocenate of baryta forms very large and regular crystals. In vacuo over sulphuric acid it loses 2·41 p. c. water, and the dry salt contains 44 p. c. baryta.

SABADILLIC ACID.

Syn. Cevadic Acid. Discovered by Pelletier and Caventon in the seeds of Veratrium Sabadilla. From the oil which ether extracts from the seeds, the sabadillate of baryta is obtained in the same way as butyrate of baryta from butter. When this salt is heated with concentrated phosphoric acid, the sabadillic acid sublimes in white needles, which are fusible at 70°, and have the smell of butyric acid. Its composition is unknown.

CROTONIC ACID.

Syn. Iatrophic Acid. Discovered by Pelletier and Caventon in the seeds of Croton tiglium. It is obtained from the oil (croton oil) exactly in the same way as the preceding acid. It is solid, very volatile, has a pungent and nauseous smell, a burning taste, and is very poisonous. Croton oil contains some free crotonic acid. The salts of crotonic acid are generally soluble and crystallizable, and have no smell. The composition of the acid is unknown.

CAMPHORIC ACID.

Formula of the anhydrous acid, $C_{10}H_7O_3$. Symb. $\overline{Ca}$. (Malaguti, Laurent, Walter.)

Formula of the hydrated acid, $C_{10}H_7O_3 + HO$. Symb. $\overline{Ca}$, HO. Discovered by Kosegarten. The anhydrous acid was first obtained by Malaguti and Laurent.

To prepare it, camphor is digested with a large excess of nitric acid till it is entirely dissolved, fresh acid being added as often as may be required. The acid solution being evaporated, yields impure camphoric acid. It is purified by combining it with potash, which separates any camphor that may have escaped oxidation. The camphorate of potash is then decomposed by nitric acid, when pure hydrated camphoric acid crystallizes. It forms small scales or needles, of a taste at first sour, then bitter. When distilled, it is resolved into water and anhydrous acid.

The salts of camphoric acid, with the alkalies and alkaline earths, are soluble and crystallizable. The other camphorates are insoluble, or sparingly soluble.

Camphorate of Ammonia. *a.* Neutral. $\overline{Ca},AdH_2O$. *b.* Acid. $3\overline{Ca} + \left.\begin{matrix}2AdH_2O \\ HO\end{matrix}\right\} + 9aq.$

Camphorate of Oxide of Ethule. *a.* Acid. $2\overline{Ca}\left.\begin{matrix}AeO \\ HO\end{matrix}\right\}$ (Malaguti). Obtained by heating camphoric acid, alcohol, and sulphuric acid together. The addition of water causes the new compound to separate. It is a colourless syrupy liquid, which, by boiling with water, is resolved into camphoric acid, and neutral camphorate of oxide of ethule. It forms with alkalies and bases in general a series of double salts, in which the atom of water is replaced by its equivalent of base.

b. Neutral. The neutral camphorate of oxide of ethule, or camphoric ether, $\overline{Ca},AeO$, is obtained by dissolving in alcohol the product of the distillation of the acid salt. When the alcohol deposits no more crystals of camphoric acid, the addition of water separates the camphoric ether as an oily liquid, sp. g. 1·029. It boils at 545°. Its formula is $\overline{Ca},AeO$. When acted on by chlorine, it yields chlorocamphoric ether, $\overline{Ca},C_4H_3Cl_2O$. (Malaguti.)

The so-called anhydrous camphoric acid, $C_{10}H_7O_3$, is obtained by crystallizing in alcohol the product of the distillation of hydrated camphoric acid, or of the acid camphorate of ethule. It forms long, flat, colourless prisms, which have no sour taste. By very long-continued boiling with water it is dissolved, and passes into hydrated acid. (Laurent.)

The existence of anhydrous organic acids is very doubtful. The substances which are supposed to be so, are in general but imperfectly known. From the action of heat on tartar-emetic, and from the composition of the succinate of lead lately described by Fehling, it appears that the so-called anhydrous tartaric and succinic acids still contain some water capable of being replaced by bases; and, according to Malaguti, the anhydrous camphoric acid forms different salts from the hydrated acid. It is probable that all such acids differ from the common hydrates, in a manner analogous to that in which the modifications of phosphoric acid differ from each other.

Of the salts of anhydrous camphoric acid but little is known; but they are decidedly distinct from the salts of the hydrated acid, and they do not yield the hydrated acid when decomposed by acids, but a gummy mass, which soon hardens, and is soluble in alcohol.

Anhydrous camphoric acid combines with fuming sulphuric acid, with disengagement of sulphurous acid. When the solution is heated, a large quantity of pure carbonic oxide is disengaged, and an acid is left, which, according to Walter, is $C_9H_7O_5S = (C_{10}H_7O_3 + SO_3) - CO$. This explanation does not account for the production of sulphurous acid in the first stage of the process. Walter has analysed the salts of this new acid, but the results are not quite decisive. Probably a purer and more permanent compound might be obtained by the action of the vapour of anhydrous sulphuric acid on anhydrous camphoric acid.

APPENDIX TO CAMPHORIC ACID.

CAMPHOR AND OIL OF CAMPHOR.

In the Camphor-tree of Sumatra and Borneo, *Dryabalanops camphora*, and of Japan, *Persea camphora*, camphor and oil of camphor are found, chiefly in those parts of the wood which in resinous trees contain the resin. The wood is split up, and the solid masses of camphor are taken out. By distilling the wood with water, an additional quantity of camphor is obtained, along with the volatile oil.

Oil of Camphor. — Formula, $C_{20}H_{16}O$ (Martius, Macfarlane). The oil of commerce contains camphor dissolved, which it deposits in crystals by evaporation. By repeated rectification the oil may be obtained colourless: it is a very mobile liquid, refracting light strongly; of sp. g. 0·91. Its boiling point lies above 212°. It absorbs oxygen from the air. By distillation with nitric acid it yields camphor, which differs from it in containing exactly twice as much oxygen. With hydrochloric acid it forms a neutral solid compound, insoluble in water. Oil of camphor dissolves phosphorus, iodine, and sulphur; and is miscible with sulphuric and acetic acids, fixed and volatile oils, ether and alcohol. It forms a stiff jelly with powdered copal.

Camphor.—Formula, $C_{10}H_8O$ (Dumas; Blanchet and Sell). Obtained as above described. According to Dumas, the crystalline substance deposited by oil of lavender is identical with common camphor. Camphor is a white, crystalline, translucent solid, somewhat tough, but easily pulverised when moistened with alcohol. Its sp. g. is 0·9857 to 0·996.* It melts at 347°, and sublimes entirely with ebullition at 400°. The density of its vapour is 5·317. (Dumas.) It evaporates readily in the air. Fragments of camphor, when thrown on water, evaporate more rapidly than when dry, and are thrown into a rotatory motion, arising from the simultaneous formation of the vapours of water and camphor.

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* A very fine specimen of genuine Borneo camphor, in the possession of Dr. Christison, consists of small fragments heavier than water. This variety of camphor, which has seldom reached Europe, being purchased at an enormous price and highly prized by the Chinese and Japanese, merits a special investigation. Its smell is not exactly the same as that of ordinary camphor, but slightly alliaceous.—W. G.

Camphor is combustible, and burns with a smoky flame. It is soluble in 1000 parts of water, but is said to dissolve easily when boiled with water under increased pressure. Ten parts of alcohol dissolve twelve of camphor. It is also soluble in proof spirit and in ether. The solution in proof spirit (camphorated spirit) is precipitated by water. Fixed and volatile oils, and bisulphuret of carbon, dissolve it. It is miscible by fusion with sulphur and phosphorus. With iodine it forms a brown compound; in chlorine gas it liquefies without apparent decomposition. Oil of vitriol dissolves it; and, when the solution is heated, it yields sulphurous acid gas, and an oil smelling of peppermint and camphor. Nitric acid dissolves camphor, and, when the solution is boiled, it is gradually converted into camphoric acid.

Camphor is used in medicine both internally in the form of emulsion, and externally in the form of ointment. Internally it acts as a diffusible stimulant, but in large doses it is poisonous. It increases the solubility of copal in alcohol, and hence is an ingredient in copal varnish.

Camphrone. — When the vapour of camphor is passed over quicklime at a low red heat, a volatile liquid is obtained among the products, which appears to have the formula $C_{30}H_{21}O$. (Fremy.) This is camphrone. If the same experiment be performed at a white heat, the products are naphthaline, $C_{20}H_8$, olefiant gas, marsh gas, and carbonic oxide gas. (Fremy.)

VALERIANIC ACID.

Formula of the anhydrous acid, $C_{10}H_9O_3$. Symb. $\overline{Va}$. Formula of the hydrated acid, $C_{10}H_9O_3,HO$. Symb. $\overline{Va},HO$. (Ettling; Dumas.)

This acid has already been described as a product of the action of caustic potash on hydrated oxide of amule (oil of potato spirit); and as existing in the root of Valeriana officinalis. (See p. 985.) Besides the hydrated acid above mentioned, there exists another hydrate, $\overline{\mathrm{Va}},3HO$, which is obtained when a strong solution of any of its salts is decomposed by an acid.

The salts of valerianic acid are generally soluble, and have a slight smell of valerian. The valerate of oxide of ethule, $\overline{\mathrm{Va}},AeO$, may be obtained by the action of heat on a mixture of alcohol, oil of vitriol, and valerianic acid. It is an oily liquid, with a penetrating smell of fruit and of valerian; of sp. g. 0·894. (Otto.)

The valerate of oxide of amule, or at least a liquid having the composition $C_{20}H_{20}O_4 = \overline{\mathrm{Va}},AylO$, is obtained by the action of heat on a mixture of oil of vitriol, hydrated valerianic acid, and bichromate of potash. (Dumas and Stass.) It is an oily liquid, which requires a careful investigation. The valerates of metallic oxides are anhydrous, and their general formula is $\overline{\mathrm{Va}},MO$.

ACTION OF CHLORINE ON VALERIANIC ACID.

Chlorovalerisic Acid.—When valerianic acid is acted on in the dark by chlorine gas, a new acid is produced, the formula of which is $C_{10}H_7Cl_3O_4$. If we compare this with hydrated valerianic acid, $C_{10}H_{10}O_4$, it appears that chlorovalerisic acid may be regarded as valerianic acid in which 3 eq. of hydrogen are replaced by 3 eq. of chlorine, without the general character of the compound being changed. The new acid is a viscid liquid, devoid of smell, and is easily soluble in alkalies.

Chlorovalerosic Acid.—When the action of chlorine is assisted by sunlight, another new acid is formed, the formula of which is $C_{10}H_5Cl_4O_3$ in the anhydrous state. It is anhydrous valerianic acid, $C_{10}H_9O_3$, in which 4 eq. of hydrogen have been replaced by 4 eq. of chlorine. Its hydrate is $C_{10}H_5Cl_4O_3 + 3HO$. With bases it forms salts very similar to the salts of valerianic acid. The chlorovalerosate of silver is $C_{10}H_5Cl_4O_3,AgO$.

These very remarkable compounds were discovered by Dumas and Stass. They are good examples of the law of substitution proposed by Dumas, the original type of the compound being retained.

According to Löwig, valerate of lime, when distilled, yields an oily liquid, valerone, $C_9H_9O = C_{10}H_9O_3 - CO_2$. The same chemist states that valerianic acid is in the valerian combined with oxide of glycerule, producing a peculiar fat; but this is doubtful.

ŒNANTHIC ACID.

Formula of the anhydrous acid, $C_{14}H_{13}O_2$. Formula of the hydrated acid, $C_{14}H_{13}O_2,HO$. (Pelouze and Liebig.)

This acid occurs in most fermented liquors, especially in wine and corn spirit, combined with oxide of ethule. When wine is distilled, this compound passes over at the end of the process in small quantity. By digestion with potash, œnanthate of potash is obtained, and from this salt the acid is separated by sulphuric acid, in the form of an oily liquid, which rises to the surface. At 54° it is semi-solid. It has neither taste nor smell; is insoluble in water, soluble in alcohol and ether. In this state it is the hydrated acid. When distilled, it is resolved into water and anhydrous acid.

Of the salts of œnanthic acid only the œnanthate of oxide of ethule is well known. This is the oil obtained by distilling wine or other fermented liquors, at the end of the distillation. It is purified from a little free œnanthic acid by heating it with a weak solution of carbonate of potash, when the pure oil rises to the surface. Its formula is $C_{18}H_{18}O_3 = C_{14}H_{13}O_2 + C_4H_5O$. (Pelouze and Liebig; Mulder.) It is a mobile oily colourless liquid, having a strong smell of wine. Sp. g. 0·862. It boils at 435°. By the action of potash it is resolved into œnanthic acid and alcohol.

It is to be observed, that this singular compound is not the cause of that peculiar fragrance in certain wines which is called the bouquet or aroma; but, on the contrary, of that somewhat unpleasant smell which is found in every kind of wine, and which is so characteristic that we can always tell by it whether a bottle or cask has been used for containing wine, even when the vessel has been for some time empty.

ROCCELLIC ACID.

Formula of the crystallized acid, $C_{17}H_{16}O_4$ (Liebig). Discovered in Roccella tinctoria by Heeren. It is extracted from the lichen by ammonia, and the solution precipitated by chloride of calcium. The roccellate of lime is decomposed by weak hydrochloric acid, when the roccellic acid separates. It is purified by solution in ether and crystallization. It forms fine white needles, fusible about 295°. In its general character it resembles the oily acids. Its salts have been little studied.

VERATRIC ACID.

Formula of the acid in the salt of silver, $C_{18}H_9O_7$. Formula of the hydrated acid, $C_{18}H_9O_7,HO$. (Schrötter.) Discovered by Merck in the seeds of Veratrum Sabadilla. The seeds are exhausted by a mixture of alcohol and sulphuric acid, and the solution precipitated by milk of lime. The veratrate of lime remains in solution. It is decomposed by hydrochloric acid, and the new acid crystallizes. It forms short white transparent prisms, which are soluble in water and alcohol, insoluble in ether. When heated they melt, and are volatilized without residue.

Its salts are for the most part soluble. It forms with oxide of ethule a crystalline compound, $C_{22}H_{14}O_8 = C_{18}H_9O_7 + C_4H_5O$. (Will)

CUMINIC ACID.

Formula of the hydrated acid, $C_{20}H_{11}O_3 + HO$. (Gerhardt and Cahours.) To obtain it, Roman oil of cumin is dropped into melted potash, when hydrogen is disengaged, and cuminate of potash is formed. The addition of an acid causes the cuminic acid to separate. The hydrated acid is a white crystallized solid, which is soluble in alcohol and volatile. Its salts are not known.

According to Gerhardt and Cahours, Roman oil of cumin is a mixture of two oils, one of which is a carbo-hydrogen, and the other analogous to the hyduret of benzule, having the formula $C_{10}H_{11}O_2 + H$. The radical of this oil they call Cumyle $= C_{10}H_{11}O_2$.

According to Völkel the common oil of cumin or caraway, from *Carum carui*, contains two oils, analogous to the foregoing; but his analyses do not agree with the above formula. By the action of the air, or by that of sulphuric acid and bichromate of potash, Roman oil of cumin is converted into cuminic acid.

CARYOPHYLLIC ACID.

Formula uncertain. Discovered by Bonastre in oil of cloves, and first obtained in a state of purity by Ettling. Oil of cloves contains this acid, mixed with an oil, $C_{10}H_8$. The addition of potash separates this oil, while caryophyllate of potash is formed. This salt, distilled with sulphuric acid and water, yields the hydrated acid, which is an oily liquid of sp. g. 1·079, with a strong smell of cloves.

The analyses of this acid, by Böckmann and Ettling, lead to the empirical formula $C_{24}H_{15}O_5$. But a comparison of the salt of baryta with the hydrated acid rather leads to the formula $C_{20}H_{12}O_4 = C_{20}H_{11}O_3 + HO$ for the hydrated acid.

According to Dumas, if the cloves be first treated with alcohol, which dissolves a crystalline substance, caryophylline, and afterwards distilled with water, an acid is obtained, which has the formula $C_{20}H_{13}O_5$, and thus appears to contain 1 at. water more than the acid above mentioned. This latter acid forms with potash an acid salt, which according to Dumas is $C_{40}H_{24}O_{10} + KO$; but which is more probably $C_{40}H_{25}O_9 + KO = 2C_{20}H_{12}O_4 + \left.\begin{matrix}KO.\\HO.\end{matrix}\right\}$

The carbo-hydrogen above mentioned may be supposed to pass into caryophyllic acid by the substitution of 4 eq. oxygen for 4 eq. hydrogen. Thus $2C_{10}H_8 = C_{20}H_{16}$; and $C_{20}H_{16} - H_4 + O_4 = C_{20}H_{12}O_4$.

Alcohol, as above mentioned, extracts from cloves a solid substance, caryophylline, which appears to be closely connected both with the carbo-hydrogen and with the acid. According to Dumas and Ettling, its formula is $C_{20}H_{16}O_2$, or $C_{10}H_8O$, which is identical with that of camphor; from which, however, it differs in being inodorous, and not volatile without decomposition.

The distilled water of cloves deposits another substance in yellowish pearly scales, to which Bonastre has given the name of Eugenine. The analysis of Dumas gives for it the same formula as for caryophyllic acid.

All these substances require to be further studied.

COCOIC ACID.

Formula of the acid in the salt of silver, $C_{27}H_{26}O_3$.

Formula of the hydrated acid, $C_{27}H_{26}O_3 + HO$. (Bromeis.)

This is the crystallizable acid contained in the butter or fat of the cocoa-nut. This fat is white, of the consistence of lard; melts about 70°, and congeals a little above 60°; has an unpleasant cheesy smell and taste, and becomes readily rancid. It is distinguished from most fats by its ready solubility in alcohol.

To obtain the acid, the fat is converted into soap by boiling with an alkali, and the soap decomposed by a mineral acid. The fatty acid mixture obtained is subjected to strong pressure to remove the liquid acid (probably oleic acid), and the pressed cocoic acid is further purified by a second saponification. The soap is repeatedly dissolved in water and separated by the addition of common salt, by which means it is rendered colourless. It is then decomposed by tartaric acid, and the fatty acid crystallized from alcohol till its melting point becomes constant.

It is snow-white, inodorous, and melts at 95°, congealing into a mass like wax. When melted with oxide of lead, it loses 4 eq. water.

With the alkalies it forms salts which are soaps, like the salts of the more common oily acids. The cocoate of oxide of ethule is obtained by passing hydrochloric acid gas into a solution of cocoic acid in alcohol, and adding water. It is a colourless mobile liquid, having a pleasant smell of apples. The cocoate of silver is white and insoluble.

SERICIC ACID.

Syn. Myristic Acid. Discovered by Playfair. Formula of the acid in the salts of baryta and potash, $C_{28}H_{27}O_3$. Formula of the crystallized acid, $C_{28}H_{27}O_3 + HO$. (Playfair.)

This acid exists in combination with oxide of glycerule in the butter of nutmegs, which are the fruit of Myristica moschata. This butter is soluble in 4 parts of hot alcohol, and the solution deposits on cooling silky crystals of sericate of oxide of glycerule (sericine or myristine). From this purified fat the acid is obtained by the usual process for oily acids, as described for the preceding acid. It is purified by repeated crystallization from alcohol or ether.

It forms brilliant white scales of a silky lustre (hence its name), fusible about 120°, and congealing into a crystalline mass. It is soluble in alcohol and ether, and is decomposed by nitric acid, and by heat.

The salts which sericic acid forms with alkalies are distinguished from other soaps by not forming viscid solutions when concentrated, and by not becoming turbid when diluted, as ordinary soaps do. Sericate of oxide of ethule is a colourless mobile liquid, of sp. g. 0·864. Formula, $2\,\overline{\mathrm{Se}} + \left.\begin{matrix}\mathrm{AeO.}\\ \mathrm{HO.}\end{matrix}\right\}$

Sericate of oxide of glycerule, or sericine, exists in the butter of nutmegs. It is purified by washing with alcohol, pressure, and solution in hot ether, from which it crystallizes on cooling. According to Playfair, its formula is $C_{118}H_{113}O_{15} = 4(C_{28}H_{27}O_3) + C_6H_5O_3$. This would give for the oxide of glycerule in this fat the formula $C_6H_5O_3$. Whereas, according to Pelouze, oxide of glycerule is $C_6H_7O_5$. But it is not impossible, as Liebig has suggested, that there may be more than one oxide of glycerule. According to Lecanu, oxide of glycerule is $C_6H_6O_4$; and it will be seen that these three formulæ only differ in the proportion of water. Liebig supposes that these different varieties of glycerine may require different quantities of acid for neutralization, just as some acids are monobasic, others polybasic. He considers stearine a compound of 2 at. stearic acid, 1 at. oxide of glycerule $= C_6H_7O_5$ and 2 at. water; while in sericine, the oxide of glycerule $C_6H_5O_3$, which contains 2 at. of water less, is combined with 2 at. of acid more, 4 at. in all. It has also been supposed by Liebig that oxide of glycerule may be $= C_3H_2O$, in which case the formula of sericine may be $\overline{\mathrm{Se}} + \mathrm{GlyO}$, or possibly $2(\overline{\mathrm{Se}},\mathrm{GlyO}) + 2(\overline{\mathrm{Se}},\mathrm{HO})$. Like all compounds of glycerule, sericine, when distilled, yields the pungent vapour of the substance to be afterwards mentioned, which is called by Berzelius Acroleine. These views are highly ingenious, and promise to throw much light on the constitution of the oils and oily acids; but they require extensive and minute researches to establish them. This subject will be again considered when we come to give a general sketch of these important compounds.

Sericic acid, when heated with potash and a little water, forms a beautiful white soap, which crystallizes out of alcohol. This, as well as the sericate of baryta, is composed according to the general formula $\overline{\mathrm{Se}},\mathrm{MO}$.

Sericate of silver appears to contain water, a rare occurrence in a salt of silver. If so, its formula is $2(\overline{\mathrm{Se}},\mathrm{AgO}) + \mathrm{HO}$. But it is more probably $\overline{\mathrm{Se}},\mathrm{AgO}$.

Sericate of lead, like some other salts of lead, when prepared from the acetate, contains acetate of lead. Its formula is $C_{116}H_{111}O_{15},7PbO = 4(C_{28}H_{27}O_3,PbO) + (\bar{A},3PbO)$.

Playfair, to whom we are indebted for the above and other facts, remarks that sericic acid is not far removed in composition from œnanthic acid. In fact, 2 at. œnanthic acid $= C_{28}H_{26}O_4$ represent 1 at. sericic acid in which 1 eq. of hydrogen has been replaced by 1 eq. of oxygen. It is thus related to œnanthic acid, as hyduret of benzule is to benzoic acid, at least as far as the formulæ are concerned; but no conversion of the one into the other has been observed.

Besides sericine, the butter of nutmegs contains a reddish fat and an aromatic volatile oil. The reddish fat, when distilled, yields, among other products, a black fat, soluble in alcohol and ether. These products have not been further examined.

PALMITIC ACID.

Formula of the acid in the salt of silver, $C_{32}H_{31}O_3$. Formula of the hydrated acid, $C_{32}H_{31}O_3 + HO$. (Fremy, Stenhouse.) Discovered by Fremy in palm oil. To obtain it, the oil is saponified by a caustic alkali, and the soap decomposed by an acid. The oily acid which separates contains some oleic acid, which is removed by solution in alcohol, and by pressure.

In appearance the palmitic acid resembles margaric acid, forming pearly scales. It has also the same melting point, namely 140°. It is saponified by digestion with the carbonated alkalies. It is partly decomposed by distillation. By chlorine it is acted on in a way similar to valerianic acid, yielding a variety of acid oils, in which hydrogen is more or less completely replaced by chlorine, and which retain their chlorine in combining with alkalies.

Palmitine, or palmitate of oxide of glycerule, is the principal solid ingredient of the palm oil or butter. It is purified by pressure, washing with hot alcohol, and finally crystallization from hot ether. It is white and crystalline, very sparingly soluble in hot alcohol, but very soluble in hot ether. It melts at 118°, and congeals to a mass like wax, which is friable. According to Stenhouse, its formula is $C_{35}H_{33}O_4$, which would indicate a compound of 1 at. anhydrous palmitic acid, $C_{32}H_{31}O_3$, united to C_3H_2O; which is the same formula for glycerine as one of those mentioned under the preceding acid as suggested by Liebig. This is possibly derived from ordinary glycerine, $C_6H_7O_5$; for $C_6H_7O_5 - 3HO = C_6H_4O_2 = 2(C_3H_2O)$. Like all the compounds of glycerule, palmitine when distilled yields the penetrating vapours of acroleine.

CETULIC ACID.

Syn. Aethalic Acid. Composition and formula identical with those of palmitic acid, from which, however, it differs in properties. (Dumas and Stass.) Formed by the action of fused potash on ethal (hydrated oxide of cetule). Symbol, $\overline{\text{Cet}}$.

The formula of ethal is $C_{32}H_{34}O_2$; that of cetulic acid is $C_{32}H_{32}O_4$. The latter is therefore produced from the former, 2 eq. of hydrogen being replaced by 2 eq. oxygen. The oxygen is derived from the water of the hydrate of potash, so that 4 eq. of hydrogen are set free in the process, 2 from this source, and 2 from the ethal. To prepare the acid, 1 part of ethal is heated with 6 parts of a mixture of fused potash and quicklime in equal proportions, to the temperature of about 425°. Hydrogen is set free, and cetulate of potash is formed. This salt is converted, by means of chloride of barium, into cetulate of baryta, which is purified from ethal by digestion in ether. The cetulate of baryta is decomposed by diluted hydrochloric acid, when cetulic acid is obtained in the form of a fat, fusible at 130°, volatile, insoluble in water, soluble in alcohol and ether. Its salts have the general formula $\overline{\text{Cet}},MO$. They have been little studied.

MARGARIC ACID.

Formula of the anhydrous acid, $C_{34}H_{33}O_3$, or $C_{68}H_{66}O_6$. Symb. $\overline{\text{Mr}}$. Formula of the hydrated acid, $C_{68}H_{66}O_6 + 2HO$. (Varrentrapp, Redtenbacher, Bromeis, Stenhouse.) Symbol, $\overline{\text{Mr}},2HO$. A bibasic acid? Discovered by Chevreul. Syn. Margarulic Acid.

Margaric acid, one of the most widely distributed and most important of the oily acids, is found in combination with oxide of glycerule, (glycerine, sugar of oils,) in several species of animal and vegetable fats and oils, particularly in human fat, in goose fat, and in olive oil, being in these cases mixed or combined with oleate of oxide of glycerule. It is also produced by the action of heat on tallow (stearate of oxide of glycerule) and on stearic acid, and by the oxidation of stearic acid.

The easiest method of obtaining pure margaric acid is to heat hydrated stearic acid with its own weight of nitric acid for some minutes. The fatty acid which separates on cooling is exposed to pressure to remove oleic acid, and purified by repeated crystallization in alcohol, till its melting point becomes constant. It may also be obtained by decomposing pure margarate of lead or of lime by a diluted mineral acid.

Margaric acid has the aspect of a fat, fusible at 140°. Its solution in alcohol has an acid reaction. From ether or alcohol it crystallizes in pearly scales; hence its name.

With bases it forms two series of salts: *a*. Neutral, the general formula of which is $\overline{\mathrm{Mr}} + 2\mathrm{MO}$; *b*. Acid, the general formula of which is $\overline{\mathrm{Mr}} + \left.\begin{matrix}\mathrm{MO}\\ \mathrm{HO}\end{matrix}\right\}$ (Varrentrapp).

SALTS OF MARGARIC ACID.

Margarate of Oxide of Ethule.—$\overline{\mathrm{Mr}},2\mathrm{AeO}$. (Varrentrapp.) Prepared by the action of hydrochloric acid gas on an alcoholic solution of margaric acid, and purified by washing with boiling water. It has the appearance of a fat, which melts at about 70°.

The *margarates of potash and soda* are obtained pure by the following method, which we owe to Chevreul. The fat of man, or of the goose, or olive oil, is saponified by boiling with caustic potash or soda. The soaps obtained are decomposed by a mineral acid; and the fatty acid which separates, a mixture of margaric and oleic acids, is heated with 8 parts of water, and potash or soda added till a clear solution is obtained. This solution is then mixed with 50 times its volume of water, which causes the separation of acid margarate of the alkali in pearly scales. These are again dissolved in 8 parts of water, the solution again rendered clear by potash or soda, and again mixed with 50 volumes of water. This operation is repeated till the salt, when decomposed, yields an acid fusible at 140°. The salt is then free from oleate of potash or soda. The acid margarate of potash is $\overline{\mathrm{Mr}},\left.\begin{matrix}\mathrm{KO}\\ \mathrm{HO}\end{matrix}\right\}$. Heated with as much more potash as it already contains, it yields the neutral salt, $\overline{\mathrm{Mr}},2\mathrm{KO}$, which is a regular soap, of a rather soft consistence, soluble both in water and alcohol, but which, when mixed with much water, yields free potash and the acid salt, the latter being insoluble.

The *margarates of soda*, acid and neutral, are quite analogous to those of potash; but the neutral margarate of soda is a somewhat harder soap.

The margarates of baryta, strontia, and lime, are insoluble, white, curdy precipitates. Margarate of lime is easily obtained pure, by dissolving in potash the first half of the products of the distillation of stearic acid, precipitating by chloride of calcium, and boiling the precipitate repeatedly with ether, to remove margarone and a carbo-hydrogen, with which it is contaminated. The purified salt is employed to yield margaric acid.

With oxide of lead, margaric acid forms a neutral, an acid, and a basic salt, all insoluble. The latter is fusible at 212°, and is a true plaster, as the salts of oxide of lead with oily acids commonly are.

Margarate of Oxide of Glycerule.—Syn. Margarine. This compound is unknown in a state of perfect purity, but is the principal ingredient of human fat and of goose fat, combined with the corresponding oleate. It occurs also in a smaller proportion in olive oil, and probably in many other fats and oils. The crystals deposited by a hot alcoholic solution of human fat are a chemical compound of margarate and oleate of glycerule. (Chevreul.) So also are the crystals which form in olive oil when it is exposed to cold. (Pelouze, Boudet.)

The original analyses of Chevreul, which, however, appear to have been made with a margaric acid not quite free from oleic acid, suggest a somewhat different formula from that given above; but the close relation between margaric and stearic acids renders the formula of Varrentrapp more probable. After describing, therefore, stearic acid, we shall give a connected view of these very interesting acids, as far as our knowledge of them at present extends.

STEARIC ACID.

Syn. Hypomargarulic Acid. Discovered in 1811 by Chevreul. Studied by Redtenbacher. Formula of the anhydrous acid, $C_{68}H_{66}O_5$. Symb. $\overline{St}$. Formula of the hydrated acid, $C_{68}H_{66}O_5 + 2HO$. (Redtenbacher.) A bibasic acid?—and the most interesting and important of all the oily acids.

It is best obtained from the stearic acid of commerce, which is used as a substitute for wax in making candles. This commercial acid is prepared by saponifying ox or mutton fat by boiling with potash, precipitating by chloride of calcium, and decomposing the stearate of lime thus formed by a mineral acid. The mixture of stearic and oleic acids thus obtained is freed as far as possible from oleic acid by pressure between warm metallic plates. It thus yields a hard mass like wax. To purify it completely, it is repeatedly crystallized from hot alcohol, till its point of fusion becomes constant at 167°. Stearic acid may also be obtained from the acid stearate of potash, (see that salt,) but still requires to be purified by alcohol, till it acquires the above melting point.

Stearic acid is a firm white solid. When melted, it congeals at 158° into a crystalline mass, which feels greasy, but is pulverizable, and insoluble in water. From alcohol it is deposited in brilliant pearly scales. In the liquid state, at 170°, its sp. g. is 0·854; in the solid state it is 1·01. It is very soluble in ether. It burns like wax, with a clear white flame.

When distilled, it is converted into margaric acid and margarone. Heated with nitric acid, it is first converted into margaric acid; and, by the continued action of nitric acid, the latter is converted into succinic and suberic acids.

STEARIC ACID AND BASES.

As a bibasic acid, stearic acid forms two series of salts. *a*. Neutral. Formula, $\overline{St},2MO$.

b. Acid. Formula, $\overline{St},\left.\begin{matrix}MO\\HO\end{matrix}\right\}$. Stearic acid partially decomposes the alkaline carbonates in the cold, yielding bicarbonate and acid stearate of the alkali. With the aid of heat it expels the carbonic acid entirely, forming a neutral stearate, which is a complete soap, in the case of potash or soda.

Stearate of Ammonia.—Hydrated stearic acid absorbs 2 eq. of ammonia, forming a white inodorous solid. It is soluble in ammonia, but deposits crystals of the acid salt, the formula of which is $\overline{St},AdH_2O,HO$. (Chevreul.)

Stearate of Oxide of Ethule.—*a*. Neutral. $\overline{St},2AeO$. This is formed, according to Lassaigne, by heating together stearic acid, alcohol, and oil of vitriol. An oily liquid rises to the surface, which solidifies on cooling.—*b*. Acid. $\overline{St},\left.\begin{matrix}AeO\\HO\end{matrix}\right\}$. When hydrochloric acid gas is passed through an alcoholic solution of stearic acid, this compound separates. It resembles wax, and melts between 80° and 90°. It crystallizes from alcohol, and is decomposed by boiling with potash, yielding stearic acid and alcohol. (Redtenbacher.)

Stearate of Oxide of Methule, neutral, according to Lassaigne, is formed like the neutral compound of ethule, which it resembles.

Stearate of Oxide of Glycerule.—This compound, the stearine of Chevreul and Lecanu, is, according to Pelouze and Liebig, an acid salt. Formula, $2\overline{St} + GlyO + 2HO$. It is the chief ingredient in most kinds of suet or tallow, and is the most important of the fatty bodies.

To obtain pure stearine, mutton suet is melted in the water-bath, mixed with ten parts of ether, and set aside to cool. The crystals which are deposited on cooling are strongly pressed, and washed with cold ether. They are pearly scales, which feel soft, but not greasy; fusible about 140° to 145°; and congealing to a mass like wax, not crystalline, and easily reduced to powder. It is insoluble in water, soluble in hot alcohol and ether; both of which solvents, on cooling, deposit almost the whole of the stearine. When distilled, it yields the products of the action of heat on stearic acid, which are margaric acid and margarone, besides a carbo-hydrogen, as well as the products of the distillation of glycerine, particularly acroleine.

Stearine has weak acid properties. By careful management it may be made to combine with potash, forming a compound from which acids separate stearine, and not stearic acid. The probable formula of this compound is $2\overline{St} + GlyO + \left.\begin{matrix} KO \\ HO \end{matrix}\right\}$.

But when stearine is boiled with caustic alkalies, stearate of potash is formed, while hydrated oxide of glycerule (glycerine) is separated. From 100 parts of stearine, Chevreul obtained 102·6 parts of hydrated stearic acid and glycerine together; the glycerine weighed 8 parts. If we admit that 3 at. of water are taken up in this process, two by the half of the stearic acid, and one by the glycerine, 100 parts of stearine should yield, according to the formula of Pelouze and Liebig, 102·3 parts of stearic acid and glycerine; the latter weighing 7·9 parts. This close correspondence not only lends additional probability to the formula given above, but is a wonderful proof of the accuracy of Chevreul in his splendid researches on fatty bodies, made when nothing was known of these compounds.

According to Pelouze and Boudet, the solid part of the butter of cacao is a compound of the above stearate of oxide of glycerule with the corresponding oleate.

Stearate of Potash.—*a.* Acid. $\overline{\mathrm{St}},\left.\begin{matrix}\mathrm{KO}\\ \mathrm{HO}\end{matrix}\right\}$. (Chevreul.) To prepare it, the solution of 1 part of the neutral stearate is diluted with 1000 parts of water, when the acid salt separates. It is purified by washing with water and solution in alcohol, from which it crystallizes in pearly scales. One thousand parts of boiling water form with 1 of this salt a milky solution, which contains neutral stearate dissolved; while the suspended salt is a still more acid compound, $2\overline{\mathrm{St}},\mathrm{KO},3\mathrm{HO}$. Three atoms of acid stearate, $3(\overline{\mathrm{St}},\mathrm{KO},\mathrm{HO})$, produce 1 atom of neutral salt, $\overline{\mathrm{St}},2\mathrm{KO}$; and 1 at. of the new salt, $2\overline{\mathrm{St}},\left.\begin{matrix}\mathrm{KO}\\ 3\mathrm{HO}\end{matrix}\right\}$. The latter is fusible into an oily liquid, while the original acid salt is only softened by heat. (Chevreul.)

b. Neutral. $\overline{\mathrm{St}},2\mathrm{KO}$. When equal weights of stearic acid and potash are dissolved in 10 parts of hot water, the neutral salt separates on cooling in opaque grains, which are to be squeezed and purified by solution in hot alcohol, from which it crystallizes in shining scales and needles. With 10 parts of cold water, this salt forms an opaque viscid solution. It is soluble in 25 parts of hot water; more soluble in solution of potash. From this latter solution, when hot and saturated, the addition of chloride of potassium separates the salt entirely in the form of an opaque viscid mass, which, on cooling, forms a firm soap. If chloride of sodium be employed, the salt which separates is neutral stearate of soda, which on cooling forms a very hard soap.

Neutral stearate of potash, as above described, is resolved by 1000 to 5000 parts of cold water into potash, which remains dissolved, and acid stearate, which separates. (Chevreul.) The neutral salt is soluble in hot alcohol, and on cooling forms a jelly (opodeldoc). It is insoluble in ether.

Stearates of Soda.—*a.* Acid. $\overline{\mathrm{St}},\mathrm{NaO},\mathrm{HO}$. Prepared from the neutral salt like the corresponding salt of potash, which it resembles.—*b.* Neutral. It is prepared like the neutral soap of potash from 20 parts of stearic acid, 13 of soda, and 300 of water. It may be obtained either in crystals from alcohol, or as a hard soap from water by adding chloride of sodium to the hot saturated aqueous solution, an excess of soda being also present. The action of water and alcohol on this soap is much the same as on the neutral salt of potash, only the soda soap is less soluble and less easily decomposed by water, requiring at least 2000 parts.

The *Stearates* of Baryta, Strontia, and Lime, are all neutral, according to the general formula, $\overline{St},2MO$. They are white insoluble precipitates.

Neutral Stearate of Lead, $\overline{St},2PbO$, resembles the preceding.

Basic Stearate of Lead, $\overline{St},4PbO$, prepared by boiling stearic acid with subacetate of lead, is a transparent soap or plaster fusible at 212°.

Acid Stearate of Lead is formed by melting 100 parts of stearic acid with 21 of oxide of lead. It is also a transparent soap or plaster, fusible at 212°.

ON THE COMPOSITION OF STEARIC AND MARGARIC ACIDS.

As already mentioned, the recent researches of Varrentrapp, Redtenbacher, Bromeis, and Stenhouse, lead to the following formulæ for the two hydrated acids:

Hydrated margaric acid, $C_{68}H_{68}O_8$ or $C_{34}H_{34}O_4$.
Hydrated stearic acid, $C_{68}H_{68}O_7$.

Margaric acid forms with oxide of silver a salt, the formula of which is $C_{34}H_{33}O_3,AgO$, so that the hydrate might be supposed to be $C_{34}H_{33}O_3,HO$; but as it forms two series of salts, in one of which only half this quantity of water is replaced by a base, we are induced to consider it a bibasic acid, $C_{68}H_{66}O_6,2HO$. The margarate of silver will then be $C_{68}H_{66}O_6,2AgO$. Taking this view, and comparing it with stearic acid, we find it to contain 1 atom of oxygen more than that acid, while the carbon and hydrogen remain exactly in the same proportion. If we now call this compound of carbon and hydrogen margarule $= C_{34}H_{33} = Ml$, we find that anhydrous margaric acid $= 2(MlO_3)$ and anhydrous stearic acid $= Ml_2O_5$. Again, comparing 1 atom $= \frac{1}{2}$ equivalent of margaric acid, $= MlO_3$, with 1 equivalent of stearic acid, we find them to bear the same relation to each other as sulphuric and hyposulphuric acids, SO_3 and S_2O_5. The only difference is, that while sulphuric acid is monobasic as well as hyposulphuric acid, the two acids of margarule, which may be called margarulic and hypomargarulic acids, are both bibasic.

If this be really the relation between margaric and stearic acids, if they be different oxides of the same radical, we should expect to be able to convert stearic (hypomargarulic) acid into margarulic acid by oxidising agents. This is in fact the case, as formerly described. The change is effected by the action not only of nitric acid, but of a mixture of sulphuric acid and bichromate of potash. Moreover, just as hyposulphuric acid, S_2O_5, is resolved by heat into sulphurous acid, SO_2, and sulphuric acid, SO_3, so hypomargarulic (stearic) acid, when distilled, is resolved into oxide of margarule (margarone), MlO, and margarulic acid, MlO_3; that is, in both cases, one portion yields oxygen to another; thus,

$$S_2O_5 = SO_3 + SO_2 \text{ and } 2Ml_2O_5 = 3MlO_3 + MlO.$$

All these facts render it almost certain that the above is a true account of the constitution of margaric and stearic acids.

The original analyses of Chevreul, indeed, gave for anhydrous margaric acid the formula $C_{70}H_{65}O_3$, or the half of this $= \frac{C_{70}H_{65}O_3}{2}$; and for anhydrous stearic acid the formula $C_{70}H_{67}O_5$. But not only was the method then used for determining the atomic weights of the acids inferior to that now employed, but the acids themselves were possibly not absolutely pure. It is worthy of remark, however, that Berzelius, observing that in these acids, according to Chevreul, the same quantity of carbon, 70 atoms, was combined with 3 and 5 atoms of oxygen, was the first to suggest that they were most probably oxides of the same carbo-hydrogen. This suggestion appears now to be established, and is only another instance of the profound sagacity of Berzelius.

It should also be mentioned here, that five careful analyses of stearine (acid stearate of oxide of glycerule), by Pelouze and Liebig, gave the following results:

Carbon . .	75·981	to	76·600	per cent.
Hydrogen .	12·240	to	12·170	per cent.
Oxygen . .	21·779	to	21·330	per cent.

Adopting for stearic acid the formula of Chevreul, and for oxide of glycerule that of Pelouze, these numbers correspond to the formula $2\overline{St}$,GlyO,2HO, which has been given above. But if we take for stearic acid the formula of Redtenbacher, and for oxide of glycerule the formula C_3H_2O, the formula most nearly agreeing with the numbers will be $\overline{\mathrm{St}}$,GlyO,2HO. The former gives $C_{146}H_{143}O_{17}$, the latter $C_{71}H_{70}O_{8}$. The former would give

Carbon	76·21	the latter,	Carbon	76·43
Hydrogen	12·18	,,	Hydrogen	12·30

Both are obviously near the truth; but, as long as there is any doubt as to the composition of oxide of glycerule, that of stearine cannot be satisfactorily determined. Notwithstanding the improvements which have been introduced into organic analysis, and the progress which has been made in the study of these substances, the results obtained by Chevreul in his masterly researches have undergone but little modification, except in the interpretation of the analytical part of his immortal work; the numerical results being correct in a degree quite wonderful, when we consider the difficulties then attending organic analysis; and, above all, that the whole subject of the fatty bodies was then untouched, insomuch that, till Chevreul discovered them, the oily acids were unknown, and the nature of soaps altogether misunderstood.

ACTION OF HEAT ON STEARIC AND MARGARIC ACIDS.

When these acids are distilled, they yield a product, the melting point of which is almost the same as that of the acids; and hence they were formerly supposed to distil nearly unchanged, although Chevreul had observed that the product was no longer entirely soluble in alkalies.

Redtenbacher and Varrentrapp have lately examined this subject minutely, with the following results.

Pure stearic acid, melting at 158°, yields a solid product, which melts at about 156°. This is a mixture of pure margaric acid, melting at 140°, and a neutral crystalline fat melting at 190°, besides a liquid substance. This mixture is dissolved by potash, forming a milky liquid, which is precipitated by chloride of calcium. The precipitate, boiled with ether, leaves pure margarate of lime; while the ether being evaporated leaves the solid and liquid neutral compounds above mentioned. The former is margarone; the latter a carbo-hydrogen.

When stearic acid is distilled with one quarter its weight of quicklime, carbonate of lime is left in the retort, while margarone and the carbo-hydrogen distil over.

It is particularly to be observed, that the products of the distillation of stearic and margaric acids contain no substance soluble in water, and particularly no *sebacic acid.*

Margarone.—Discovered by Bussy. Obtained by distilling stearic or margaric acids with or without lime. It is purified by crystallization from ether.

Margarone is a white, crystalline, friable fat, fusible generally at 190°, but sometimes at 200° and upwards; indicating the existence of more than one compound, the composition of which, however, seems to be nearly uniform. The analyses of margarone by Bussy, Redtenbacher, and Varrentrapp indicate two formulæ, between which it is difficult to decide. The first is $C_{33}H_{33}O$, which may arise from anhydrous margaric acid by the loss of 1 at. carbonic acid; $C_{34}H_{33}O_3 - CO_2 = C_{33}H_{33}O$. This would account for the agency of lime in its production. Again,

4 at. hydrated stearic acid . $=\underline{C_{272}H_{272}O_{28}}$ might yield

$$\left.\begin{array}{lllll} \text{6 at.=3 eq. hydrated margaric acid} & C_{204} & H_{204} & O_{24} \\ \text{1 at. water} \quad . \quad . \quad . & & H & O \\ \text{1 at. margarone} \quad . \quad . \quad . & C_{33} & H_{33} & O \\ \text{1 at. carbonic acid} \quad . \quad . & C & & O_2 \\ \text{1 at. carbo-hydrogen} \quad . \quad . & C_{34} & H_{34} & \end{array}\right\} = C_{272}H_{272}O_{28}$$

On the other hand, if we adopt for margarone the formula $C_{34}H_{33}O = MlO$, then

$$\begin{array}{ll} \text{2 at. hydrated stearic acid} & =Ml_4O_{10}+4HO \text{ yield} \\ \text{3 at. hydrated margaric acid} & =Ml_3O_9 +3HO \\ \text{1 at. margarone} \quad . & =Ml\ O \\ \text{1 at. water} \quad . \quad . & = \qquad HO \\ \hline & Ml_4O_{10}+4HO. \end{array}$$

From the margarone the carbo-hydrogen may be formed along with carbonic acid and carbon; for 2 at. margarone $= C_{68}H_{66}O_2 = C_{66}H_{66} + CO_2 + C$. That this does happen is indicated by the deposition of carbon. The formation of margarone from margaric acid and lime is also easily explained.

2 at. anhydrous margaric acid $=\underline{C_{68}H_{66}}O_6+$2 at. lime, 2CaO, yield

$$\begin{array}{llll} \text{1 at. margarone=MlO} & =C_{34}H_{33}O & & \\ \text{2 at. carbonate of lime} & =C_2 \quad O_4+ & & 2CaO \\ \text{1 at. of water} & = \quad HO & & \\ \text{Polymeric carbo-hydrogen} & =C_{32}H_{32} & & \\ \hline & C_{68}H_{66}O_6+ & & 2CaO \end{array}$$

From stearic acid with lime Redtenbacher obtained a compound like margarone, but composed of $C_{46}H_{45}O$. This may be a compound of oxide of margarule with a carbo-hydrogen, $C_{34}H_{33}O + C_{12}H_{12} = C_{46}H_{45}O$.

A similar compound, discovered by Bussy, and called by him stearone, is $C_{68}H_{66}O$. It is possibly Ml_2O, a sub-oxide of margarule.

In all these researches the carbo-hydrogens were found to contain equal equivalents of hydrogen and carbon; but, as they form no combinations from which their atomic weights can be deduced, it is impossible to say whether they may contain one equivalent of each element, or a certain number of CH in one atom. In fact, there appears to be an unlimited number of such carbo-hydrogens, agreeing in relative proportions, but differing in the absolute quantity of their elements; in other words, in their atomic weight.

PRODUCTS OF THE ACTION OF NITRIC ACID ON STEARIC AND MARGARIC ACIDS.

If stearic acid be heated with an equal weight of nitric acid, sp. g. 1·285, for a few minutes, it is entirely converted into margaric acid, while the nitric acid contains no foreign substance. But if the action be continued, the nitric acid being occasionally renewed, the margaric acid is by degrees entirely decomposed, and the liquid on cooling deposits nothing. If evaporated to one half, it deposits *suberic acid;* and contains succinic acid, and an oily liquid soluble in nitric acid. (Bromeis.)

Suberic Acid.—Formula of the anhydrous acid, $C_8H_6O_3$. Symb. $\overline{Su}$. Formula of the crystallized acid, $C_8H_6O_3,HO$. Symb. $\overline{Su},HO$. Discovered by Brugnatelli as the product of the oxidation of cork by nitric acid; by Laurent as a product of the action of nitric acid on oleic acid and olive oil; and by Bromeis as a product of the action of nitric acid on stearic and margaric acids.

The solution of margaric acid in nitric acid after long boiling is evaporated to one half, when it deposits a quantity of crystals. These are washed with cold water, and purified by crystallization. They are hydrated suberic acid. From cork it is obtained by a similar process. It forms a white crystalline powder; fusible, if moist, at 130°, and if dry, at 238°. In a higher temperature it sublimes, condensing into an oily liquid, which congeals into long needles. It is easily soluble in hot water, alcohol, and ether.

In the salts of suberic acid, 1 atom of basic water is replaced by 1 at. of base. Suberate of oxide of ethule is an oily, fragrant liquid, $\overline{Su},AeO$. The alkaline suberates are soluble. Those of baryta, strontia, lime, and silver, are neutral and insoluble. With oxide of lead suberic acid forms a neutral salt, $\overline{Su},PbO$; and a basic salt, $\overline{Su},3PbO$. (Bromeis.)

When suberate of lime, baryta, or strontia is distilled with excess of base, there is obtained, among other products, a liquid boiling at 367°, which absorbs oxygen from the air, or from nitric acid, and is converted into suberic acid. According to Boussingault, its formula is C_8H_7O. It may be considered as a hyduret of suberule, $C_8H_6O + H$, analogous to hyduret of benzule. It may also be the oxide of another radical, C_8H_7.

Succinic Acid. — Formula of the anhydrous acid, $C_4H_2O_3$. Symb. $\bar{S}$. Formula of the sublimed acid, $C_8H_5O_7 = 2\bar{S} + HO$. Formula of the hydrated acid, $C_4H_2O_3,HO = \bar{S},HO$.

Succinic acid exists ready formed in amber (succinum), and in the resins of certain coniferæ. (Unverdorben, Lecanu, and Serbat.) It is also one of the products of the oxidation of stearic and margaric acids.

To obtain it, the products of the distillation of amber are filtered through moistened paper, to separate empyreumatic oil; the filtered liquid is evaporated, and the crystals which it deposits are purified by sublimation. To prepare it from the oily acids, the mother liquid of the suberic acid, as above described, is evaporated, and the crystals which separate are purified from suberic acid by cold ether, which dissolves the latter.

Hydrated succinic acid crystallizes in colourless scales or prisms, of sp. g. 1·55, which are entirely volatile. The sublimed acid contains only half the quantity of water, and by repeated sublimation it may be rendered at last anhydrous.

Anhydrous sulphuric acid acts on it, producing a new acid, in which 2 at. of sulphuric acid and 1 of hydrated succinic acid combine, the elements of 1 at. of water becoming basic. Its probable formula is $C_4H_2S_2O_9,HO$.

Succinic acid, contaminated with the empyreumatic oil formed in the distillation, has been, and still is occasionally, used in medicine. The oil is the active ingredient, probably from containing kreosote.

Succinamide.—This substance is formed by the action of aqua ammoniæ on succinate of oxide of ethule. It is a crystalline solid. Formula, $C_4H_2O_2 + NH_2 = \bar{S},Ad$. It differs from succinate of oxide of ammonium by 2 at. of water. (Liebig.)

Bisuccinamide.—When anhydrous succinic acid is heated in dry ammonia, a crystalline volatile body is obtained, which D'Arcet calls Bisuccinamide. Its formula is $C_8H_3O_4 + NH_2 = (C_8H_4O_6 + NH_3) - 2HO = (2\bar{S} + AdH) - 2HO$. When bisuccinamide is dissolved in water, the solution yields crystals, the formula of which is $C_8H_7NO_6 = (C_8H_4O_6 + NH_3)$; that is, anhydrous bisuccinate of ammonia. But it does not appear to be that salt, but rather bisuccinamide with 2 at. water (of crystallization ?) (D'Arcet).

Some uncertainty exists in regard to the true constitution of succinic acid and its salts. According to the prevailing view, the salts of succinic acid have the general formula, $C_4H_2O_3 + MO$. But Fehling, by recent researches, has rendered it probable that succinic acid is a tribasic acid, and that the hydrated acid is $C_8H_3O_5 + 3HO$. According to this chemist, the following is a view of the succinates.

$$C_8H_3O_5 + AdH_2O \quad = \text{crystallized succinamide. (Bisuccinamide.)}$$

$$C_8H_3O_5 + 3PbO \quad = \text{tribasic salt of lead.}$$

$$C_8H_3O_5 + \left.\begin{matrix}2PbO\\HO\end{matrix}\right\} = \text{bibasic salt of lead.}$$

$$C_8H_3O_5 + \left.\begin{matrix}2AdH_2O\\HO\end{matrix}\right\} = \text{bibasic salt of ammonia.}$$

$$C_8H_3O_5 + \left.\begin{matrix}2AgO\\HO\end{matrix}\right\} = \text{bibasic salt of silver.}$$

All the succinates are decomposed by distillation.

Succinate of Ammonia.—The solution of the neutral salt is used in analysis to precipitate peroxide of iron. It deposits crystals, which are permanent in the air, and volatile, while the liquid becomes acid. An impure solution was formerly used in medicine.

Succinate of Oxide of Ethule is an oily liquid, of sp. g. 1·036 in the liquid state, and 6·06 in the state of vapour. It boils at 417°. With aqua ammoniæ it forms a crystalline substance, apparently analogous to oxamethane (D'Arcet). The remaining succinates are of little importance. Those of lead and silver are white and insoluble.

Succinone.—When succinic acid is distilled with lime, an oily liquid is obtained, to which D'Arcet has given the name of Succinone. As his analyses of it do not agree together, its formula must be considered unknown.

APPENDIX TO SUCCINIC ACID.

AMBER.

The origin of this well-known substance is still doubtful. It is commonly viewed as having been originally a vegetable balsam or resin, altered by time. But the production of succinic acid from oily acids renders it probable that amber is a product of the decay of wax, or of some other substance allied to the fats or fixed oils.

It is found on the coast of Prussia partly in beds of fossil wood or brown coal, partly on the shore, and at the bottom of the sea. After storms it is found on the shore among the sea-weeds torn up by the agitation of the water. To judge by the remains of vegetables which accompany it, it is the produce of extinct coniferæ, and it frequently contains insects almost always of extinct species. One species is said to exist at the present day in America, and species allied to others occur in Brazil and New Holland. Amber occurs sparingly in other parts of Europe, as in the neighbourhood of London and Paris, Sweden, Poland, Italy, Spain; and also in Siberia and North America; but generally in beds of fossil wood, brown coal, or coal.

Amber occurs in fragments of various sizes. It is transparent or translucent, hard, brittle, of a paler or darker yellow or brown colour, of sp. g. 1·065 to 1·07; tasteless and inodorous, but acquiring an aromatic smell when heated. It becomes highly electric by rubbing, and was the first substance in which this property was observed; hence the term electricity (from ηλεκτρον, amber). It melts at about 550°, but is partially decomposed at that temperature. It is insoluble in water, partially soluble in alcohol.

Amber, according to Berzelius, contains succinic acid, a volatile oil, two resins soluble in alcohol and ether, and a bituminous mass insoluble in all menstrua. This last constitutes more than four-fifths of the amber. According to Hünefeldt, hydrochloric acid extracts from amber, besides succinic acid, another acid, very similar to mellitic acid. When amber is distilled, it yields succinic acid, and a volatile oil (oil of amber); while the bituminous residue, dissolved in a mixture of linseed oil and oil of turpentine, forms amber varnish. According to Vogel, a yellowish substance is found along with the acid and oil, which he calls camphor of amber.

The oil of amber is a mobile liquid, of a penetrating smell. It is an ingredient of Eau de Luce, along with alcohol and ammonia, and is used as a stimulating essence in cases of fainting. This oil, when acted on by nitric acid, yields an orange-coloured resinous mass, with a strong musky smell (artificial musk).

OLEIC ACID.

Formula of the acid in the salt of baryta, $C_{44}H_{39}O_4$? Formula of the hydrated acid, $C_{44}H_{39}O_4,HO$? (Varrentrapp.)

According to the analysis of Chevreul, oleic acid is a bibasic acid, and the formula of the hydrate is $C_{70}H_{58\frac{1}{2}}O_5,2HO$. According to Laurent, it is $C_{70}H_{64}O_5,2HO$. But the absolute purity of the acid analysed by Chevreul is doubtful, and that analysed by Laurent had been distilled, in which circumstances it is decomposed. There is reason, however, to believe that there is more than one liquid oily acid, to which the name of oleic acid has been given. The oleic acid of Varrentrapp was obtained from oil of almonds, and from the fluid portion of ox fat. The acid of Chevreul was obtained from the fluid portion of mutton suet.

Oleic acid, combined with oxide of glycerule, is the principal ingredient of the fixed oils, excepting the drying oils. It occurs in smaller quantity in animal fats, probably in large quantity in liquid animal oils; also in bile along with stearic acid; and in the seeds of cocculus indicus.

To obtain oleic acid, almond oil must be preferred, as containing more of it than olive oil, or the fluid portion of animal fats. The drying oils, according to Redtenbacher, contain a distinct acid.

Oil of almonds is saponified, and the soap decomposed by an acid. The resulting oily acid is digested in the water-bath for several hours with half its weight of oxide of lead. The mixture is then agitated with twice its volume of ether, and left for twenty-four hours. The ether dissolves acid oleate of lead, leaving undissolved margarate of lead. The clear ethereal solution is now mixed with diluted hydrochloric acid, when the oleic acid is separated, and rises to the surface dissolved in ether. The ether is removed by gentle evaporation, and the oleic acid again saponified by soda. The soap is now purified by being repeatedly dissolved in solution of soda, and separated by the addition of common salt, by which means it may be rendered colourless, or nearly so. The purified soap yields oleic acid hardly coloured, which is washed with water to remove free mineral acid, and deprived of water by the heat of the water-bath.

Oleic acid thus prepared is an oily liquid, having a slight smell and a pungent taste. It is decidedly acid to test paper, lighter than water, and crystallizes in needles when cooled some degrees below 32°. It is insoluble in water, soluble in alcohol and ether, miscible with oils and fats.

It is decomposed by heat, yielding sebacic acid and other products. Nitric acid converts it into suberic acid and several other acid products; but does not produce any oxalic acid. By nitrate of mercury, or nitrous acid, it is converted into elaidic acid. Of all the oily acids, it is the most easily decomposed.

SALTS OF OLEIC ACID.

Oleic acid decomposes the alkaline carbonates, forming with potash and soda soft soaps. The formulæ of the oleates are not yet determined with certainty.

Oleate of Ammonia.—A gelatinous mass, soluble in cold water.

Oleate of Oxide of Ethule.—A colourless, tasteless, inodorous, oily liquid, of sp. g. 0·871, volatile, easily decomposed by an alcoholic solution of potash. In contact with nitrate of mercury, it is converted into elaidate of oxide of ethule. (Laurent.) It may be distilled with little change. Probable formula, $C_{44}H_{39}O_4$,AeO.

Oleate of Oxide of Methule.—Analogous to the preceding.

Oleate of Oxide of Glycerule.—Syn. Oleine. Unknown in a state of perfect purity. It is an ingredient in almost all oils and fats, in which it is mixed or combined with stearate or margarate of oxide of glycerule, or both. When these oils are subjected to pressure at a low temperature, the more fluid portion is impure oleine, generally containing in solution some compound of oleine with stearine or margarine.

According to Kerwyk, a tolerably pure oleine may be obtained from olive oil, by agitating 2 parts of the oil with 1 of a strong solution of caustic soda, and then adding weak alcohol, when the unsaponified portion rises to the surface. It is washed with weak alcohol, and dried by fragments of chloride of calcium. When animal fat is boiled with alcohol, the hot liquid deposits on cooling stearine and margarine, retaining oleine in solution; and, by repeating this process, it may be got nearly pure.

According to Pelouze and Boudet, the fluid part of fat oils contains two compounds; and the oleine of drying oils is distinguished by the action of nitrous acid. This acid converts the oleine of fat (not drying) oils into a solid mass—elaidate of oxide of glycerule, or elaidine; while it has no apparent action on the oleine of drying oils.

The physical properties of oleine are similar to those of almond oil. Its sp. g. is 0·90 to 0·92. It is converted by alkalies into soap, with the separation of glycerine. By the action of heat or of nitric acid it is converted into the same products as oleic acid, with the addition of the products yielded by glycerine. It absorbs oxygen from the air, and becomes thick. It congeals when exposed to a very low temperature.

Oleate of Potash.—a. Neutral. This compound is formed by heating equal weights of oleic acid and potash with 5 parts of water. It separates from the liquid as a soft mass, which is purified by solution in alcohol, and evaporation to dryness. It forms a white, dry, friable mass, of a bitter alkaline taste. It forms with 2 parts of water a jelly; and dissolves in 4 parts of water, forming a viscid, soapy solution. When the soap made from mutton suet is treated with water, as described under stearic and margaric acids, whereby acid stearate and margarate of potash are precipitated, and when the process has been repeated till water causes no further turbidity, the filtered liquid contains oleate of potash or soda nearly pure. From the salt thus made, the oleic acid of Chevreul was prepared. The solution of oleate of potash precipitates most of the earthy and metallic salts.

b. Acid. This salt is formed by heating 100 parts of oleic acid, about 9 of potash, and 400 of water together. It forms a jelly, insoluble in water, but soluble in alcohol.

Oleate of Soda.—The neutral salt is formed like that of potash, which it much resembles.

The *oleates* of the earths and metallic oxides are insoluble in water, fusible when heated, and soluble in alcohol.

Oleate of Lead is obtained pure by precipitating acetate of lead with impure oleate of potash or soda, made from almond or olive oil, and digesting the precipitate with its own weight of ether, which leaves undissolved margarate and stearate of lead. The oleate of lead softens by the heat of the hand, and has all the properties of a plaster. Oleic acid forms with oxide of lead, besides this neutral oleate, an acid and a basic salt, which are also plasters.

ON THE COMPOSITION OF OLEIC ACID.

It has already been mentioned, that Chevreul obtained from the oleic acid of mutton suet, a different formula from that adopted by Varrentrapp in his recent researches for the oleic acid of oil of almonds and of ox tallow. The differences in their results are so considerable, as to render it probable that they examined different acids. For example, Chevreul found in the oleate of baryta 22·97 p. c. of baryta; while the salt of baryta analysed by Varrentrapp contained only 18·38 p. c. But there is reason to doubt the perfect accuracy of Chevreul's formula, even supposing the acids to be different, from the occurrence in it of a half equivalent of hydrogen.

There can be little doubt of the accuracy of Varrentrapp's formula for the acid analysed by him; for not only was the acid quite free from stearic and margaric acids, but in ten analyses he obtained numbers closely agreeing with his formula; and these analyses were made on oleic acid from different preparations, both as first obtained, and after its saponification or combination with bases, and subsequent separation. Moreover, the analysis of the oleate of oxide of ethule agrees closely with Varrentrapp's formula, $C_{44}H_{39}O_4,AeO$; and the same remark applies to the analysis of the oleates of baryta and silver.

Further experiments are still required to complete our knowledge of the true constitution of oleic acid.

ACTION OF HEAT ON OLEIC ACID.

When oleic acid is heated, it boils at a high temperature, and is thereby decomposed, yielding solid, liquid, and gaseous products. The gaseous products are carbonic acid and carburetted hydrogen. The liquid portion contains a little undecomposed oleic acid, with several liquid carbo-hydrogens, the boiling point of which varies from 320° to 526°. The solid product, which is most abundant in the first stage of the distillation, is a new acid discovered by Thénard, and called by him Sebacic Acid. This acid is a characteristic product of the distillation of oleic acid from every source, including that from drying oils, and of all fats containing a liquid acid.

SEBACIC ACID.

Formula of the anhydrous acid, $C_{10}H_8O_3$. Formula of the hydrated acid, $C_{10}H_8O_3,HO = \overline{Sb},HO$. (Dumas. Redtenbacher.)

To obtain it, the whole liquid and solid products of the distillation of oleic acid, oleine, oils, or fats, are boiled with water as long as that liquid deposits anything on cooling. The crystals are washed with cold water, and crystallized from hot water till they become colourless, and free from empyreumatic smell.

Hydrated sebacic acid forms light, white, pearly scales, very like benzoic acid. They melt at 260° to an oily liquid; and at a higher temperature sublime unchanged. It is sparingly soluble in cold water; very soluble in hot water, alcohol, and ether.

SALTS OF SEBACIC ACID.

The cold aqueous solution of sebacic acid causes a white precipitate in the salts of lead or silver. The general formula of the sebates is $\overline{Sb},MO$.

The *Sebates of Potash, Soda, and Ammonia*, are very soluble and crystallizable. Their solutions precipitate the salts of lime, forming sebate of lime. $\overline{Sb},CaO$. (Redtenbacher.)

Sebate of Silver, $\overline{Sb},AgO$, is a white, curdy precipitate, which, when heated, leaves 51·64 p. c. of metal, and yields a sublimate resembling sebacic acid.

Sebate of Oxide of Ethule. $\overline{Sb},AeO$. Prepared like the ethers of the oily acids generally, by passing hydrochloric acid gas through a solution of the acid in alcohol, and adding water, which separates the new compound. A mobile oily liquid, having a fragrant smell of melons; crystallizable at 16°, and volatile at a temperature above 212°.

The presence of sebacic acid among the products of the distillation of any oil or fatty substance may be considered as positive proof of the presence in that oil or fat of oleic acid, or of a liquid acid closely analogous. Even the drying oils, although the oleic acid they contain appears to be distinct, yield sebacic acid when distilled; while, on the other hand, those oily acids which are solid at ordinary temperatures, such as stearic, margaric, or sericic acids, do not yield the smallest trace of sebacic acid. To ascertain, then, whether an oil, a fat, or an oily acid, contains oleic acid under any of its forms, distil a small portion of it, and boil the product with water. If the filtered liquid deposit crystals on cooling, then oleic acid has been present in considerable quantity. If, again, the liquid deposit nothing, but has acquired the property of precipitating the salts of lead, oleic acid has been present in smaller quantity. But if the water have dissolved nothing, no oleic acid has been present. This is a test of great delicacy, for which we are indebted to Liebig and Redtenbacher.

ACTION OF NITROUS AND NITRIC ACIDS ON OLEIC ACID.

1. *Action of Nitrate of Mercury, or of Nitrous Acid.*

By the action of nitrate of mercury, and more especially by that of nitrous acid, oleic acid is converted into a new acid, solid at ordinary temperatures, to which the name of Elaidic Acid has been given. (Poutet. Boudet. See below, *Action of Nitric and Nitrous Acid on Oils.*)

Elaidic Acid.—To prepare it, a current of nitrous acid, as disengaged from a mixture of starch and nitric acid by heat, is passed for four or five minutes through pure oleic acid at a low temperature. After a short time the liquid congeals into a crystalline mass. This is washed with hot water to remove nitric acid, and then dissolved in its own volume of hot alcohol. On standing, this solution forms a semi-solid mass of crystals, which are purified by pressure and recrystallization. (Meyer.)

Hydrated elaidic acid, thus prepared, resembles sublimed benzoic acid. It melts at 113°; is extremely soluble in alcohol, less so in ether, insoluble in water. When distilled, a great part passes over unchanged; but the product, when boiled with water, yields a solution which precipitates the salts of lead and silver, but deposits no crystals. (Meyer.)

SALTS OF ELAIDIC ACID.

Elaidic acid decomposes the alkaline carbonates, forming salts which, with 6 to 8 parts of water, yield strong soapy solutions.

Neutral Elaidate of Soda is soluble in alcohol, and crystallizes like the acid. Its solution in water when diluted, deposits an acid salt, like stearate and margarate of soda.

Elaidate of Silver is a white curdy soap, which may be obtained in crystals from its solution in aqua ammoniæ.

Elaidates of Lead and Baryta are both white and insoluble.

Elaidate of Oxide of Ethule, prepared by the same process as the other fatty ethers, is an oily liquid, which is decomposed by alkalies. (Laurent. Meyer.)

Elaidate of Oxide of Glycerule.—Syn. Elaidine. This is the compound produced when oleine (oleate of oxide of glycerule) is acted on by nitrous acid or nitrate of mercury. (See *Action of Nitrous Acid on Oils and Fats.*)

ON THE COMPOSITION OF ELAIDIC ACID.

The production of elaidic acid from oleic acid is still unexplained, as it is accompanied by other products not yet sufficiently studied. Among these is a dark red viscid oil, soluble in potash with a blood-red colour, but not forming a soapy solution. (Meyer.)

Laurent observed that oleate of oxide of ethule was changed by nitrate of mercury into elaidate of oxide of ethule, and attributed the change to a simple absorption of oxygen from the nitric or nitrous acid. According to that chemist, oleic and elaidic acids are oxides of the same radical. Thus,

Hydrated oleic acid . = $C_{70}H_{66}O_5,2HO$.
Hydrated elaidic acid = $C_{70}H_{66}O_6,2HO$.

But, however simple this explanation appears, it cannot at present be adopted. Neither of the acids analysed by Laurent was pure; for his elaidic acid melted at 108°, instead of 113°; and his oleic acid had been distilled, which, as formerly mentioned, cannot be done without decomposition. Moreover, his explanation does not include the red oil above-mentioned, or any other product.

Meyer obtained in his recent analysis of elaidic acid, prepared from perfectly pure oleic acid, results indicating the following formulæ :

Anhydrous elaidic acid, $C_{72}H_{66}O_5$.
Hydrated elaidic acid . $C_{72}H_{66}O_5$,2HO.

And the analysis of the elaidates of silver and of oxide of ethule agreed closely with these numbers. Boudet's analysis of the salt of silver, made with an acid which melted at 113°, like Meyer's, had given the same result. Meyer has also shown, that when oleic ether is converted into elaidic ether, the same reddish oil is produced as when oleic is converted into elaidic acid.

If from 2 at. of oleic acid, according to the analysis of Varrentrapp $= C_{88}H_{80}O_{10}$, we subtract 1 at. of elaidic acid, hydrated
(Meyer) $= \underline{C_{72}H_{68}O_7}$, there remain the following numbers—
$C_{16}H_{12}O_3$; in which we find carbon and hydrogen in the same proportions as in acetule, C_4H_3: so that, by oxidation, acetic acid might be formed along with elaidic acid. This, however, has not been shown to occur.

The yellow or red oil above-mentioned seems to be an essential accompaniment of the production of elaidic acid. It appears to contain deutoxide of nitrogen or nitrous acid ; which explains the circumstance that no other oxidising agent, except nitrate of mercury or nitrous acid, can convert oleic into elaidic acid.

2. *Oxidation of Oleic Acid by Nitric Acid.*

The action of colourless nitric acid on oleic acid has been studied by Laurent, who has discovered among the products a series of new acids, of which one alone, namely suberic acid, was previously known to chemists. Bromeis has recently repeated his experiments, and confirmed most of his results. As the experiments of both, however, were made on impure oleic acid, containing margaric, and perhaps stearic acid, it is impossible at present to ascribe the origin of all these new compounds to the oleic acid alone.

In this action, nitric acid of sp. g. 1·42, previously diluted with its volume of water, is employed. If concentrated, the action is almost explosive. Even with the diluted acid it is at first very violent, but afterwards becomes regular and moderate; and with the aid of heat, and a proper supply of nitric acid, the oleic acid is at last entirely dissolved. The vapours of nitric and nitrous acids, which distil over during the process, carry with them a small quantity of an oily fluid, which attacks the organs of respiration, having a most pungent smell.

The solution when completed, and when margaric acid is no longer deposited on cooling, contains the following acids: suberic acid; azelaic acid; pimelic acid; adipic acid; lipic acid; and an oil soluble in nitric acid. Suberic acid is the most abundant product.

The acid solution is evaporated to one-half, and on cooling deposits a mass of crystals, which are placed to drain in a funnel stopped with asbestus, and washed with cold water. They are suberic acid. When dissolved in hot water, there generally separates an oil or fat, soluble in nitric acid, insoluble in water. When purified by crystallization from alcohol, it forms an oily acid, fusible at 86°, and soluble in alkalies with a blood-red colour.

According to Bromeis, the suberic acid thus obtained is pure; but Laurent found it contaminated with azelaic acid, which resembles it in appearance, but may be separated by ether, in which the latter is very soluble. The formula of azelaic acid, according to Laurent, is $C_{10}H_8O_4,HO$; differing from suberic acid by containing 1 at. of oxygen and 1 at. of hydrogen more. But, as it contained suberic acid, this formula is doubtful. The difference in the results of Laurent and Bromeis probably depends on the fact, that the oleic acid of the former contained margaric acid, while that of the latter contained stearic acid.

Pimelic Acid.—Formula, $C_7H_5O_3,HO$. (Laurent. Bromeis.) The liquid which has deposited the suberic acid is further evaporated, and allowed to stand for some time, when it deposits more suberic acid in light soft crystals, and pimelic acid in hard crystalline grains. These are first washed with cold water and cold alcohol, which remove most of the suberic acid, and purified by repeated solution in hot water and crystallization. It melts at 273°, and at a higher temperature sublimes in fine pearly scales.

Pimelate of Silver, $C_7H_5O_3,AgO$, is white and insoluble.

Adipic and Lipic Acids.—The mother liquid of the preceding acids is very gently evaporated, and set aside for some days. Crystals are deposited, and the liquid remaining is treated in the same way as long as it yields any crystals. The crystals are collected and purified by solution in hot water, when some of the oil formerly mentioned separates. On cooling, the solution deposits brownish crystals of adipic and lipic acids. They are dissolved in ether, and the solution allowed to evaporate to one-half. Crystals are formed, and the mother liquid, by further evaporation, yields more. The two portions are separately boiled with alcohol, and there is obtained on the one hand adipic acid in rounded grains, and lipic acid in fine long plates. Both are purified by recrystallization.

Adipic Acid forms round or hemispherical radiated masses, of a brownish colour, very soluble in hot water. It melts at 266°, and may be sublimed unaltered. All its salts, except the adipate of silver, seem to be soluble. According to Laurent, the anhydrous acid is $C_6H_4O_3$; and the hydrate, $C_6H_4O_3,HO$. According to Bromeis, the acid melts at 293°, and its formula is $C_{14}H_9O_7,2HO$; being thus a bibasic acid, derived from 2 at. of pimelic acid, by the replacement of 1 eq. hydrogen by 1 eq. oxygen. The acids analysed by Laurent and Bromeis may really be distinct, although in most properties they agree.

Lipic Acid crystallizes in long plates, and from alcohol the crystals are particularly fine. It is more soluble in water than adipic acid; and resembles oxalic acid, of which latter, however, no trace is formed in the process. It is fusible at 290°, and sublimes without change in crystals. Formula, $C_5H_3O_4,HO$. (Laurent.)

There generally remains more or less of an oily liquid on the surface of the nitric acid, with which oleic acid has been boiled till with an excess of acid no farther action is observed. According to Laurent, if this liquid be boiled with alcohol and sulphuric acid, it yields an ether, which he considers to be a compound of oxide of ethule with another new acid, *azoleic acid.* By decomposing the ether, he obtained the acid as an oily liquid, the formula of which he considers to be $C_{13}H_{13}O_4$. But, as there is no evidence of its purity, its existence and formula as a separate acid are alike doubtful. According to Bromeis, the oily liquid abovementioned contains several oily acids; one of which, when the oil is digested with alcohol, readily forms an ether, which seems to be butyrate of oxide of ethule.

Laurent states, that when equal weights of oleic acid and nitric acid are heated together, and the residue well washed and treated with alcohol, œnanthic ether is obtained, indicating the formation of œnanthic acid. But, according to Bromeis, the ether thus obtained has not the composition of œnanthic ether; and although its smell is similar, this property may belong to butyric ether, and the ethers of other fatty acids. As butyric and pimelic acids agree in composition, except that the former contains 1 eq. hydrogen more, the occurrence of butyric acid is more probable.

The acid liquid which has deposited the pimelic, adipic, and lipic acids, still contains a very soluble acid, not further examined.

ACTION OF ALKALIES AT A HIGH TEMPERATURE ON OLEIC AND ELAIDIC ACIDS.

When these acids are heated with 3 volumes of strong alkaline ley till the water is dissipated, and the alkali begins to melt, a violent effervescence occurs, owing to the escape of free hydrogen gas. Water is here evidently decomposed, its oxygen uniting with some of the elements of the oily acids. The alkali is found to be united with a new acid, and with acetic acid. If the mass be acted on with a little water, the salt of the new acid separates as a soap.

The oily acid of this soap is separated and purified in the usual way. It crystallizes from alcohol, melts at 143°, and is friable. Oleic and elaidic acids yield the same new acid. According to Varrentrapp, its discoverer, its formula is $C_{32}H_{30}O_3,HO$. This explains its formation: for if from

1 at. oleic acid . . . $C_{44}H_{39}O_4$ we subtract
1 at. of the new acid . $C_{32}H_{30}O_3$
there remain . . . . $C_{12}H_9\,O$.

Now $C_{12}H_9O + O_8 = 3(C_4H_3O_3)$, that is, 3 at. acetic acid. The 8 at. of oxygen are obtained from water, and 8 at. of hydrogen disengaged. Again, 1 at. of elaidic acid ($C_{72}H_{66}O_5$) + 7 at. of oxygen contain the elements of 2 at. of the new acid, and 2 at. of acetic acid. These are additional proofs of the accuracy of the formulæ of Varrentrapp and Meyer for oleic and elaidic acids.

ACIDS OF CASTOR OIL.

When castor oil is saponified, the soap yields a mixture of two oily acids; one solid at ordinary temperatures, the other liquid.

The former melts at 266°, forms soaps with alkalies, and has been called Margaritic Acid. Formula, $C_{35}H_{31}O_6$? (Bussy and Lecanu. Laurent.)

The latter congeals at 21°. Its properties and composition may be considered unknown.

Castor Oil.—This oil is a mixture of the compounds of oxide of glycerule with the acids last mentioned. One of these oils is a fusible margarine or fat, the other liquid. Both differ from ordinary margarine and oleine.

Castor oil is extracted from the seeds of Ricinus communis. It is, when pure, pale, viscid, and nearly devoid of taste or smell. Its use as a purgative is well known. It is completely soluble in its volume of absolute alcohol, which furnishes the means of detecting its adulteration with other oils. By nitrous acid it is slowly converted into palmine, a substance analogous to elaidine, but differing from it.

APPENDIX TO THE OILY ACIDS. NATURAL FIXED OILS AND FATS.

The term fixed oil, or fat, in general signifies a compound of oxide of glycerule with certain organic acids. Such compounds are exclusively natural products, not one having as yet been formed artificially.

Among animals they occur chiefly in the cellular membrane; among plants in the seeds, capsules, or pulp surrounding the seed; very seldom in the root. They all, when fluid or melted, make a greasy stain on paper, which is permanent. They are decomposed by acids, which combine with or destroy the oxide of glycerule; and by alkalies, which unite with the acids, setting free the oxide of glycerule. The latter process is called saponification, because the compounds of the oily acids with alkalies have the properties of soap.

The most abundant oils and fats are compounds of oxide of glycerule with stearic, margaric, and oleic acids; two of these, and often all three, being present. Indeed, neither stearate, margarate, nor oleate of oxide of glycerule is yet known in a state of purity. From what has been said of these three compounds, which for brevity we shall call stearine, margarine, and oleine, the consistence of the oil or fat depends on the predominance of one or other. Where stearine predominates, the fat is firm and solid; if margarine be most abundant, it is soft, like lard; while, if oleine predominate, it is liquid. It is obvious that a mixture of stearine and oleine in certain proportions will have the consistence of margarine.

Fixed oils and fats are generally inodorous. Where they possess a peculiar smell, this is always owing to the presence of a compound of oxide of glycerule with a volatile oily acid, such as butyric or hircic acid.

Fats are more fusible than the acids they contain; but at low temperatures they are harder. By pressure between warm plates, the greater part of the oleine of fats may be separated. The remaining fat is harder, less fusible, and less greasy, in proportion as it approaches to pure stearine. At low temperatures the oils assume exactly the aspect of fats. The solid parts of fats and oils are sometimes nearly pure stearine or margarine; in other cases they are definite compounds of stearine or margarine with oleine. Such is the case with the solid part of olive oil, and with the butter of Theobroma cacao.

Oils and fats may be divided into two well-marked classes, according to the action of atmospherical air, or of nitrous acid and nitrate of mercury, on them.

The first of these classes contains the drying oils; so called, because, when exposed to the air, they absorb oxygen, and are converted into a transparent, tough, dry mass, or varnish. The drying oils, moreover, are not solidified by nitrous acid or nitrate of mercury.

Of the nature and constitution of the drying oils, but little is known. They may be saponified by alkalies, but the acid of these soaps is different from ordinary oleic acid, and dries in the air, like the oil from which it is obtained. They also contain oxide of glycerule. Many of the drying oils contain stearine or margarine, or both, dissolved.

The second class, which may be called that of the fat oils, contains those oils and fats which do not dry on exposure to air, and which, when liquid at ordinary temperatures, are solidified by nitrous acid or nitrate of mercury.

Owing to the impurities which oils and fats in their natural state contain, such as membrane, mucus, or albumen, and which act like yeast in promoting chemical action, most of them, when kept, become rancid, as it is called. This change is produced by the absorption of oxygen in part; while the oily acids are set free, and sometimes, as in palm oil, oxide of glycerule is liberated. The rancid smell is owing to the production, at the expense of the elements of the oxide of glycerule, the impurities, and the oxygen of the air, of a volatile body which appears to be acid, as alkalies remove it. Pure stearine, margarine, and oleine do not become rancid.

ACTION OF HEAT ON OILS AND FATS.

The action of heat on oils is very remarkable. At a high temperature they boil, giving off carbonic acid with a little inflammable gas, and a substance, *acroleine*, possessed of a most pungent odour, attacking the eyes most painfully. They acquire a darker colour, and on cooling generally assume the consistence of butter or lard. Oils when distilled become more solid, fats less solid.

When the drying oils are heated, they become thick and viscid, and afterwards dry much more rapidly than before. Hence the advantage of boiling oils intended for oil varnish.

When the fixed oils and fats are distilled, they yield, besides carbonic acid and inflammable gas, a crystalline product, principally margaric acid, mixed with sebacic acid, arising from the oleic acid, acroleine, proceeding from the oxide of glycerule, and an oily liquid, insoluble in alkalies, which is commonly a carbo-hydrogen. A portion of oleic acid also distils unchanged. The first half of the product is solid, owing to the predominance of margaric acid; the second half liquid. No stearic acid is found in either; it is converted into margaric acid.

It has already been stated that the sebacic acid arises exclusively from oleic acid, whether from fat or drying oils, with the exception of castor oil, which does not yield it. Stearic and margaric acids, as well as pure stearine and margarine, do not yield a trace of it.

On the other hand, none of the known oily, or fat acids, when distilled alone, yields the smallest trace of acroleine, the substance to which is owing the insupportably pungent smell of distilled oils or fats. We can only, therefore, ascribe the origin of acroleine to the action of heat on oxide of glycerule; and, in point of fact, hydrated oxide of glycerule (glycerine), when distilled alone, yields it in large proportion. Hence the occurrence of acroleine among the products of the distillation of a fat or oil is a sure and delicate test of the presence of glycerine in the oil.

When the products of the distillation of lard or olive oil are collected in a series of well-cooled bottles containing water, the second and third bottles contain the greater part of the very volatile acroleine, partly dissolved in the oily liquid on the surface, partly in the water below. If the water be again distilled, it yields an oil, soluble in water, and having in the highest degree the insupportable smell of acroleine. Acroleine is unknown in a state of purity; and is remarkable for the rapidity with which it absorbs oxygen from the air, becoming acid. Even in close vessels its solution is decomposed, yielding a tasteless, inodorous, and very indifferent white solid, not resembling fat, and insoluble in all menstrua yet tried. No compound of acroleine has yet been formed from which it can be again obtained. This remarkable substance requires an especial study.

Castor oil, so peculiar in other respects, yields also peculiar products when heated. Among the products are acroleine, an oil insoluble in alkalies, and some peculiar fatty acids. When about one-fifth of the oil has been decomposed, the residue in the retort suddenly consolidates into a spungy elastic yellow mass, insoluble in all menstrua except strong alkalies, with which it forms a viscid solution.

The oil, insoluble in alkalies, contains a solid and a liquid compound. The fatty acids obtained are two; one solid and volatile, the other liquid; both as yet little examined. No sebacic acid occurs in this process.

When castor oil is distilled with nitric acid a volatile acid is produced, possessing the formula $C_{14}H_{13}O_3 + aq$. This formula differs from that of the œnanthic acid by 1 at. oxygen.

OIL GAS.

When fixed oils are introduced drop by drop into red-hot vessels, they are almost entirely converted into volatile products. Of these a large portion consists of permanent gases,—carbonic oxide, marsh gas, and olefiant gas,—mixed with the vapours of several very volatile liquids. This mixture is oil gas. Owing to the presence of olefiant gas, and of the vapours above-mentioned, its illuminating power is twice that of the best coal gas, and three and a half times that of ordinary coal gas. But this difference is barely sufficient to cover the increased expense of the oil employed, even when of the coarsest quality. The sp. g. of the best oil gas is 0·900.

When oil gas is strongly compressed, as in the process for rendering it portable, the vapours above-mentioned are liquefied. Faraday, who examined the liquid, discovered in it several compounds of carbon and hydrogen. One of these is pure benzole (see Benzole). Another is liquid at 0° or —1°, but gaseous at 32°. It has the same composition in 100 parts as olefiant gas, but twice the density. Hence its formula is double that of olefiant gas. It has been named quadro-carburetted hydrogen. The mixed liquid appears to contain another volatile substance, which, like the benzole, crystallizes at low temperatures, the exact composition of which is not sufficiently known ; and in the less volatile portion, another liquid, having apparently the composition, in 100 parts, of olefiant gas. The great illuminating power of oil gas is owing to the presence of the vapours of these carbo-hydrogens. For details, the reader is referred to the Memoirs of Faraday in the Philosophical Transactions.

ACTION OF SIMPLE SUBSTANCES ON FIXED OILS.

The action of oxygen has been already mentioned. The fixed oils are decomposed by chlorine and bromine, yielding hydrochloric and hydrobromic acids, along with other products not yet examined. They generally dissolve iodine, forming a brown solution. They also dissolve sulphur and phosphorus, and such solutions are occasionally used in medicine. When strongly heated with sulphur, the oils undergo a change not yet investigated. The mixture thus formed, is called balsam of sulphur. For use it is dissolved in oil of turpentine or oil of aniseed.

ACTION OF ACIDS ON FIXED OILS AND FATS.

1. ACTION OF SULPHURIC ACID.

The oils are decomposed by strong sulphuric acid. If the quantity of acid be small, it combines with the oxide of glycerule, setting free the oily acids. But when more acid is used, very remarkable changes occur, which have been studied by Fremy in the case of olive oil.

When sulphuric acid is gradually added in the cold to twice its volume of olive oil, bisulphate of the oxide of glycerule is formed on the one hand, and on the other compounds of sulphuric acid with margaric and oleic acid. The mixture becomes tough; and, if mixed after twenty-four hours with two volumes of water, the sulphates of the oily acids, being insoluble in the diluted acid, rise to the surface as a syrupy liquid. This mixture, when freed from adhering acid by washing with a little cold water, dissolves in a larger quantity of water. The sulphate of margaric acid has not yet been separated from that of oleic acid; but the solution containing these compounds is decomposed when kept, or when heated, yielding five new acids. (Fremy.)

When the solution is long kept at ordinary temperatures, the sulphuric acid separates; a mixture of two new acids, metamargaric and metoleic acids, rises to the surface; and a third, hydromargaritic acid, remains dissolved in the water along with the sulphuric acid. If the original solution be heated, there rises to the surface a mixture of these three acids, with a fourth, hydroleic acid; and, when this mixture is boiled with alcohol, there is deposited on cooling a fifth acid, hydromargaric acid, which appears to be formed by the mutual action of metamargaric and hydromargaritic acids. (Fremy.)

Metamargaric Acid.—Symb. $\overline{\text{mMr,}}$ 3HO ? The mixture deposited in the cold by the above solution is exposed to strong pressure to separate the metoleic acid, and the residue purified by crystallization from alcohol, in which the latter acid is sparingly soluble. Metamargaric acid is a white solid, fusible about 112°, and crystallizing on cooling. It is insoluble in water, soluble in alcohol and ether.

When heated with oxide of lead, it loses 3 at. of water, which appear to be replaced by 2 at. of oxide,—a very unusual occurrence, if confirmed. Its salts have been little studied; but it seems to form with potash, soda, and ammonia, neutral and acid salts, the former gelatinous, the latter soluble in alcohol and crystallizable.

Hydromargaritic Acid.—Symb. $\mathrm{h\overline{Mt}}$, 2aq.? When the solution above-mentioned has ceased to deposit any more metamargaric and metoleic acids, it is boiled, when a mixture of hydromargaritic and hydroleic acids rises to the surface. Cold alcohol removes the latter, and leaves hydromargaritic acid as a white solid, insoluble in water, but soluble in alcohol and ether. It forms colourless prisms, which are friable, and melt at 155°. By heat it is resolved into water and metamargaric acid. Its salts resemble those of the preceding acid, but are as yet little known.

Hydromargaric Acid. — Symb. $\mathrm{\overline{hMr}}$,2HO. This acid, as already stated, is formed when the mixture containing the two preceding acids, along with the two remaining ones, is boiled in alcohol. On cooling, the new acid is deposited in crystals. It is best obtained by melting together 1 equivalent of the two preceding acids, and crystallizing the mass from alcohol. It generally crystallizes in large hemispherical masses, is much more soluble than the two acids from which it is formed, and melts at 140°. It forms a series of salts, which, although analogous, are quite distinct from those of the preceding acids. By the action of heat it yields metamargaric acid.

ON THE COMPOSITION OF THE THREE PRECEDING ACIDS.

Fremy, the discoverer of these acids, has proposed a very simple explanation of their formation. Adopting for margaric acid the formula $C_{70}H_{69}O_8$, he considers metamargaric acid to be formed from it by the assimilation of the elements of two at. water; and its formula will be $C_{70}H_{73}O_{12} = C_{70}H_{71}O_{10}$,2HO. But not only is the formula thus adopted for margaric acid irreconcileable with the analyses of Varrentrapp, but the analyses of the new acids by Fremy do not sufficiently support his formulæ. Fremy adopts for hydromargaric acid the formula $C_{70}H_{71}O_{10}$, and considers it as formed from

$$\begin{array}{lll} & \text{1 at. metamargaric acid} & = C_{70}H_{73}O_{12} \\ + & \text{1 at. hydromargaritic acid} & = \underline{C_{70}H_{70}O_{9}} \\ & & \quad C_{140}H_{143}O_{21} \\ - & \text{1 at. of water} \quad . & = \underline{\quad H \quad O} \text{ leaving} \\ & \text{2 at. hydromargaric acid} & = C_{140}H_{142}O_{20} \end{array}$$

But if the preceding formula be erroneous, this cannot be a correct account of its production.

If we consider hydromargaritic acid a bibasic acid, and deduce its composition from its analysis as contained in the salt of silver, we obtain the formula $C_{74}H_{74}O_{10}$; and for the hydrate $C_{74}H_{76}O_{12}$. If now we subtract 2 at. of carbonic acid and 2 at. of water, there remain $C_{72}H_{74}O_6$; proportions which agree much more closely with the numerical results of Fremy's analysis of the anhydrous metamargaric acid than the formula which he has adopted, namely, $C_{70}H_{67}O_6$; and which, moreover, explain the conversion of hydromargaritic acid into metamargaric acid by the action of heat. With regard to hydromargaric acid, the analysis of Fremy may be better interpreted by the formulæ $C_{73}H_{75}O_9$ for the dry, and $C_{73}H_{77}O_{11}$ for the hydrated acid, than by those he has chosen. If we take the formula of the hydrated acid, on this supposition, and double it,

we have . . . $C_{146}H_{154}O_{22}$, and if we
subtract 1 at. metamargaric acid $= C_{72}H_{74}O_6$
and 1 at. hydromargaritic acid $= C_{74}H_{74}O_{10}$
there remain 6 at. of water . H_6O_6; so that

the production of this acid from the other two may be as easily explained as on Fremy's view. Hitherto, however, the atomic weights of these acids, as deduced from their salts, agree with neither of the above views.

The more recent researches of Varrentrapp and Miller have thrown some doubt on the exactness of the numerical results of Fremy, on which both the above views are founded. According to Miller, both hydromargaric and hydromargaritic acids become solid about 35° below the point at which they melt; a fact which excites the suspicion that they may both be mixtures of two distinct compounds.

Berzelius has proposed a third view of the composition of these acids, also founded on the analysis of Fremy. He assumes the existence of a radical, piotine $= C_{35}H_{35}$. Calling this $= R_2$, we have

$R_2O_3 =$ metamargaric or piotinous acid.
$R_2O_4 =$ hydromargaric or hypopiotinic acid.
$R_2O_5 =$ hydromargaritic or piotinic acid.

The resulting formulæ, when calculated to 100 parts, agree most exactly with the actual numerical results of Fremy; but not only are these doubtful, but by adopting the formulæ of Berzelius we lose all insight into the formation of these acids from margaric acid, and this is the chief object of the analytical investigation.

To show how little confidence is due to the coincidence of numbers, when unsupported by the study of the nature of the substance, and the products accompanying its formation, it may be stated, that if we choose to consider hydromargaritic acid as the acid margarate of ethule, which it certainly is not, the formula $\overline{\mathrm{Mr}},\mathrm{AeO},3\mathrm{HO} = C_{74}H_{75}O_{12}$, when reduced to 100 parts, gives numbers exactly corresponding to Fremy's analysis of the acid.

METOLEIC AND HYDROLEIC ACIDS.

These acids arise from the action of sulphuric acid on oleic acid, as the three former do from margaric acid.

Metoleic Acid.—Symb. $\overline{\mathrm{mOl}},2\mathrm{HO}$. When metamargaric acid is prepared as before described, this acid remains undissolved by the alcohol. It is purified by repeated boiling with alcohol and by exposure to cold, when the metamargaric acid crystallizes out. It is a liquid, insoluble in water, very soluble in ether, and by heat converted into carbonic acid and a carbo-hydrogen. It is distinguished from oleic and hydroleic acid by its sparing solubility in alcohol. According to Fremy, in its salts 1 at. of water is replaced by 2 at. of base, which is very unlikely.

Hydroleic Acid. — Symb. $\overline{\mathrm{hOl}},2\mathrm{HO}$. In the preparation of hydromargaritic acid, hydroleic acid is removed by cold alcohol, in which it is extremely soluble, and by which it may be purified. It forms a liquid, insoluble in water, very soluble in alcohol and ether. Heated with oxide of lead it loses 2 at. of water, which are replaced by 2 at. of oxide. In its other salts, according to Fremy, 2 at. of base only displace 1 at. of water.

When these acids are distilled, they yield carbonic acid; two liquid carbo-hydrogens, oleéne and elaéne, both having the composition of olefiant gas; and an empyreumatic oil. (Fremy.)

The two carbo-hydrogens are separated by careful rectification. Oleéne, the more volatile, boils at 131°, has an alliaceous smell, is very combustible, and appears to have poisonous properties. Elaéne boils at 230°, has a smell like that of oleéne, and is decomposed by chlorine with the production of hydrochloric acid, and a new liquid compound.

Fremy adopts for metoleic acid the formula $C_{70}H_{63}O_8,HO$; but the analysis of the salt of silver rather indicates that it is a bibasic acid, and that its formula is $C_{90}H_{85}O_{10},2HO$. This formula readily explains the action of heat; for if from 1 at. of the hydrated acid $= C_{90}H_{87}O_{12}$ we subtract 5 at. of carbonic acid and 2 of water $= \underline{C_5H_2O_{12}}$ there will remain $C_{85}H_{85}$. This may be divided into $C_{40}H_{40} =$ oleéne, and $C_{45}H_{45} =$ elaéne. The calculated density of elaéne in the state of vapour agrees with Fremy's experiment. The compound formed by chlorine seems to be $C_{45}H_{40}Cl_5$, in which 5 at. of hydrogen are replaced by 5 of chlorine.

According to Fremy, hydroleic acid only differs from metoleic acid in containing the elements of 1 at. of water more. This admits of the same explanation of the action of heat, which is the same in both acids.

2.—ACTION OF NITROUS ACID ON OILS.

It has already been stated, under the head of oleic and elaidic acids, that oleic acid is solidified by nitrate of mercury or nitrous acid. Poulet first observed this action in the case of olive oil and several other oils. Boudet showed that nitrous acid is the true agent, and that oleine (oleate of oxide of glycerule) is converted by it into elaidine, a solid fat, which is composed of elaidic acid and oxide of glycerule.

When olive oil, for example, is mixed with the common red fuming nitric acid of commerce, it is solidified by the nitrous acid present. According to the quantity of nitrous acid, the change is effected in a longer or shorter time. When a mixture of 3 parts pure nitric acid and 1 part hyponitrous acid (produced by the distillation of nitrate of lead,) was used, the following results were obtained:

1 part of the acid mixture with	33 of olive oil solidified in	70 minuets.
1	50	78
1	75	84
1	100	130
1	200	435
1	400 remained unchanged.	

The very small quantity required to produce the effect, and the fact that in several oils, castor oil for example, a similar solidification is caused by sulphurous acid, render this action a problem which is yet unresolved.

Oil of almonds, of acacia nuts, of rape seed, castor oil, and oil of hazel nuts, agree with olive oil in being solidified by nitrous acid or nitrate of mercury. The oils of linseed, hemp, walnuts, poppy seed, and other drying oils, undergo no change when mixed with these reagents, except that they are coloured brown. The presence of drying oils prevents or retards the solidification of the fat oils.

The product of the action of nitrous acid on the fat oils is the same in all cases, except in that of castor oil. A yellowish semisolid mass is formed, which when washed with alcohol becomes white, and when further purified by pressure and crystallization is pure elaidine. The yellow matter taken up by the alcohol changes to a dark brick-red by the action of alkalies.

Those oils which yield elaidine, generally contain margarine and oleine. It is at present doubtful whether the former in these circumstances yields a part of the elaidine; for pure margaric acid cannot, like oleic acid, be converted into elaidic acid. The elaidine from almond oil appears to contain oleine, and that from olive oil margarine. If this be really the case, the purest elaidine yet obtained cannot be considered as pure elaidate of oxide of glycerule. Pelouze and Boudet, however, state that when margaric acid is dissolved in oleic acid, both are entirely converted into elaidic acid. This requires confirmation.

The oleine of human fat and of hog's lard, as well as that of the oils above-mentioned, is converted by nitrous acid into elaidine. But neither the solid part of these and other fats, pure stearine, nor pure stearic acid, can be made to undergo this change.

Elaidine made from olive oil melts at about 90°. When saponified, the soap treated with acids yields elaidic acid, which is probably impure, as it melts at 107° and lower; while pure elaidic acid, made from pure oleic acid, melts at about 112°. Laurent analyzed the acid from olive oil, and has given the formula $C_{70}H_{78}O_6$. But, till we are satisfied of its purity, this formula cannot be adopted.

Palmine.—Castor oil, when treated with nitrous acid, yields a peculiar new fat, palmine, which melts at 143°. When saponified by alkalies, it yields oxide of glycerule, and a new fatty acid, palmic acid.

Palmic Acid.—The soap made from palmine and potash being purified, is decomposed by tartaric acid, and the fatty acid which separates is dissolved in cold alcohol. The solution, by spontaneous evaporation, yields pure hydrated palmic acid. It is crystallizable, and melts at 122°; it is very soluble in alcohol and ether. When boiled with alcohol, it seems to form palmate of oxide of ethule; at least, an oily liquid separates on cooling. It is partially decomposed by distillation. Its salts are little known; and the composition both of palmine and palmic acid is yet undetermined.

It is very remarkable that a current of sulphurous acid gas, when passed through castor oil, converts it into a solid mass, which seems to be palmine, and which, when saponified, yields palmic acid. That the same acid should be formed by an oxidizing and a deoxidizing agent is a fact which requires a careful investigation.

ACTION OF METALLIC OXIDES ON FIXED OILS AND FATS.

The action of alkalies and of oxide of lead on fixed oils and fats has long been practically known. The compounds produced by the former are called *Soaps:* those formed by oxide of lead are *Plasters.*

Up to 1813 soaps and plasters were considered to be compounds of alkalies and oxide of lead with oils and fats; although it was observed that the oil, when again set free, had acquired a greater solubility in alcohol, and was more readily saponifiable than before. The discovery of glycerine by Scheele was the only well-ascertained fact previous to the researches of Chevreul in 1813.

This illustrious philosopher observed that a certain kind of soap, when diluted with a large proportion of water, became turbid, and deposited a pearly substance, which he found to contain an alkali combined with an oily matter, not previously described, of decided acid properties. This observation was the origin of, perhaps, the most splendid series of investigations known in the history of chemistry; in the course of which, continued as they were for fourteen years, Chevreul not only discovered a large number of new compounds, and cleared up the whole subject of the fixed oils, fats, soaps, and plasters, but established those principles which at present prevail in the study and analysis of organic substances.

At a time when such investigations were unknown in organic chemistry, the profound sagacity of this distinguished philosopher taught him that the ultimate analysis of an organic compound was not alone sufficient to determine its true composition; but must be accompanied by a complete study of the changes produced on it by the action of reagents, and a careful determination of the quantities of the several products as well as of their composition.

This great principle, which now regulates all researches in organic chemistry, we owe to Chevreul. By it he was led to numerous discoveries, and by it also he was guarded from error, at a time when all was error in this branch of chemistry. But the example of Chevreul was not immediately followed; and it was not till Dumas and Boullay, in 1824, applied the same principle to the study of the ethers, that its application to organic chemistry in general gave rise to the extraordinary progress which, since that time, has been made in this department of the science.

Chevreul showed that the different kinds of fixed oils and fats contained three distinct compounds, united in the most various proportions: one, liquid at ordinary temperatures, which he called Oleine; and two solid, but differing in fusibility, Stearine and Margarine.

He also showed that each of these contained oxide of glycerule, (glycerine,) in combination with an oily acid; and that when the oil or fat was acted on by alkalies, or by oxide of lead or zinc, these bases united with the oily acids,—forming, in the first case, soluble soaps; in the other, insoluble plasters. The oxide of glycerule in the moment of separation united with water, forming hydrated oxide of glycerule (glycerine, or sugar of oils). When the weight of the glycerine was added to that of the oily acids, after the latter were separated from the bases, their united weights exceeded somewhat that of the original oil; which he showed to arise from the fact, that both the oily acids and the glycerine, when separated from other substances, combine with water. With ordinary oils and fats no other products are formed; but when the oil or fat contains any of the volatile oily acids, such as butyric or phocenic acids, the soap contains a salt of the volatile acid, and acquires its smell.

Soaps are divided into *hard* and *soft soaps*. The former are obtained from fats or fat oils ; the latter from drying oils. Of the hard soaps, those containing soda are firmer than the soaps of potash. Of the hard soaps of commerce, those made with vegetable oils are mixtures of oleate and margarate of potash or soda ; those made with animal fats are mixtures of stearate, margarate, and oleate of potash or soda.

In order to form soap, the oil or fat is boiled with a solution of caustic potash or soda, till the whole forms a thick viscid emulsion, which can be drawn out into long clear threads. If not clear, either water or alkali must be added, according as the turbidity depends on undecomposed oil, or on a deficiency of water. When the saponification is complete, the next step is to separate the soap from the excess of alkali, the glycerine, and the superfluous water. This may be effected by boiling down till the alkaline ley becomes very concentrated, when the soap becomes insoluble, and rises to the surface. The same end is attained by adding very strong ley, or common salt, both of which render the soap insoluble when added in sufficient quantity ; soap being absolutely insoluble in alkaline ley of a certain strength, as well as in a saturated solution of common salt. The separation is known to be complete when the liquid ceases to froth in boiling ; and the soap is ladled off into moulds, where it is well stirred to favour the separation of the liquid, which should run off from its surface like water from fat. The soap brought to this state in the first operation is called *grain soap*, from its separating in grainy particles at first. It may be further purified by repeating the process of dissolving it in alkaline ley, and separating it by the addition of salt. In this process the impurities subside, and the soap generally takes up more water ; so that, although whiter, it is less strong. White soap, for example, commonly contains 45 to 60 p. c. of water, while grain soap only contains 25 to 30 p. c. No doubt it might be again procured with as little water as at first ; but it is the fluidity caused by the additional water that allows the impurities to subside, and the soap to become white. What is called marbled soap is grain soap which has not been subjected to purification ; and the grey, blue, and green colours in it arise principally from the presence of insoluble soaps of oxide of iron or of copper.

It is to be observed, that when common salt is added to the solution of a soap of potash, the latter is converted into soda soap, entirely or partially, according to the quantity of salt, while chloride of potassium is formed. As this latter salt does not cause the soap to separate, like common salt, it is necessary to use twice as much salt to separate the soap when it has been made with potash. If a soap of potash be required, it must be separated by caustic potash. In Germany soda soap is first made with potash, and the potash soap is decomposed by common salt. In England and France, soda soap is made directly with caustic soda.

The use of salt in this important process depends on the curious fact, that soap, like muscular fibre or animal membrane, cannot be moistened by a saturated solution of salt; that is, cannot deprive it of water. On the other hand, if these substances be moistened with water, or dissolved in it, the addition of dry salt in sufficient quantity will remove the whole of the water.

Soft soaps are made with drying oils, either alone, or mixed with train oil or other fat oils. They are insoluble in strong alkaline ley, and are separated from water by the addition of potash or soda. When train oil is added, they have the disagreeable smell of that oil, arising from phocenic acid.

Such is a very general and brief account of the principles of soap-making, which are few and simple. The great experience of the makers of a substance so long known had taught them empirically how to produce good soap in a great variety of forms; but it is only of late that the rationale of their processes has been understood, and that improvements have been made on scientific principles. Soap-making may now be considered as one of the arts most thoroughly understood.

It is impossible here to describe the varieties of soap. Of the simple soaps, stearate of soda may be considered the type of hard soaps. It is hardly altered by contact with 10 parts of water. Stearate of potash, with 10 parts of water, forms a viscid solution. The margarates of soda and potash resemble the stearates. Oleate of soda dissolves in 10 parts, oleate of potash in 4 parts of water. Hence soaps are harder and less soluble, the more stearate and margarate they contain; and softer and more soluble when oleates predominate.

As the soaps of lime, baryta, earths, and metallic oxides in general are insoluble, the use of hard water, which contains salts of lime, causes a precipitation of the insoluble soap, which is very prejudicial. This may be corrected by adding to the water as much carbonate of soda or potash as is sufficient to separate all the lime, before the water is used to dissolve soap. It is in this way that soda renders hard water soft for washing and other purposes.

The soap used in medicine is a hard soap made by boiling to dryness in a gentle heat 1 part of soda ley, sp. g. 1·33, and 2 parts of olive or almond oil. It is a mixture of margarate and oleate of soda with free soda and glycerine. *Antimoniated soap* is made by dissolving 1 part of precipitated sulphuret of antimony in caustic potash, mixing the solution with 6 parts of medicinal soap, and evaporating to dryness.

PLASTERS.

There are two kinds of officinal plaster made with lead,—litharge plaster, and white lead plaster; but all the compounds of oxide of lead with the oily acids possess the properties of plaster.

Litharge plaster, or Diachylon plaster, is made by boiling 5 parts of levigated litharge (protoxide of lead) with 9 of olive oil, and some water, till the whole acquires a proper consistence and a greyish white colour. At common temperatures it is plastic; when heated, it melts. It may also be obtained by adding subacetate of lead to a solution of soap. The plaster thus formed is good at first, but afterwards becomes hard; while that prepared directly from the oil remains plastic, apparently from the presence of undecomposed oil. Litharge plaster consists chiefly of basic oleate and margarate of lead. It is the basis of almost all medicinal plasters.

White lead plaster (Emplastrum cerussæ) is made in the same way, using 16 parts of carbonate of lead to 9 of olive oil. It is white, plastic in the heat of the hand, liquid at 212°. It enters into the composition of many plasters used in medicine.

Iron plaster and *Mercurial plaster* are made by adding salts of mercury or iron to solution of soap. They are insoluble masses, softened by heat, and are not much used.

OILS AND FATS OCCURRING IN NATURE.

1.—DRYING OILS.

The drying oils are generally derived from seeds by pressure. Their distinguishing character is that of drying into a varnish by exposure to the air. This change is caused by the absorption of oxygen; and, as the impurities generally present in oils impede the access of oxygen to the particles of the oil, the drying takes place much more rapidly when these impurities are removed or destroyed. Boiling acts by destroying them, and a little litharge is added to promote the change. But a better and more colourless varnish is obtained by agitating the drying oil, linseed oil for example, with a mixture of water, litharge, and subacetate of lead, without heat. When the whole is allowed to stand, the impurities subside with the water, and the oil is so pure that it dries into a varnish in twenty-four hours. It contains a little oxide of lead, but this rather improves the varnish.

The absorption of oxygen by drying oils goes on so rapidly when their surface is much extended, that wool, shavings, tow, or other porous substances, when steeped in drying oil and exposed to the air, often take fire spontaneously from the heat developed. This is a frequent cause of fire in manufactories, where the oiled parts of the machinery are wiped with tow or cotton.

The oil or varnish for printer's ink is made by boiling drying oil till it acquires the proper consistence, and the tendency to dry quickly.

The following are the principal drying oils: —*Linseed oil*, from the seeds of *Linum usitatissimum.* It has the properties of drying oil in the highest degree. *Walnut oil*, from the kernel of the walnut, *Juglans regia.* This oil stands next to the preceding as a drying oil. *Hempseed oil*, from the seeds of *Cannabis sativa. Oil of Poppy-seed. Croton oil*, from the seeds of *Croton tiglium.* The oils of *Jatropha multifida* and *Jatropha curcas*, resembling croton oil in activity and other properties. The oils of *Euphorbium lathyris* and of *Cucurbita pepo* are also drying oils.

2.—FISH OR TRAIN OIL.

Under the name of train oil several varieties of fish oil are known. They have some resemblance to the drying oils; but are distinguished by containing, in general, one or more volatile oily acids in small quantity, generally phocenic acid. They are for the most part composed of oleine with a little phocenine. The principal varieties are whale oil, seal oil, dogfish oil, and cod's liver oil. Most fish oils contain a small quantity of a crystallizable fatty acid, not yet examined. That of the dolphin holds a portion of spermaceti dissolved. Fish oil is used for lamps, and to mix with drying oils for soft soap.

3.—LIQUID FAT OILS.

These are distinguished from the drying oils by the action of the air; if exposed to it, they are slowly altered, but remain greasy and do not yield a dry varnish. They are used both as food and for burning. They are purified from foreign matters by being agitated with a little oil of vitriol, and afterwards washed with water to remove any adhering acid. After this operation they burn much more brightly, and clog the wick much less. They are all more or less completely solidified by nitrous acid, which is not the case with drying oils.

The principal fat oils are *olive oil*, from the pulp of the olive, *Olea Europæa*, which is much used as an article of food, and for making soap. It congeals when exposed to cold, and the solid portion seems to be a compound of margarine and oleine. *Almond oil* contains much less margarine than olive oil. It therefore yields softer soap, and is better adapted to the preparation of oleic acid. *Rapeseed oil* and *Oil of Colza* are similar to olive oil, and much used as combustibles on the Continent.

The *Oil of yolk of egg* and *Oil of cow-heel* are two mild inodorous animal oils, very similar to vegetable oils. The former soon becomes rancid; but the latter, from retaining its sweetness very long, is much prized for fine salves and ointments.

4.—SOLID FAT OILS, OR FATS.

These are numerous both in the vegetable and animal kingdoms, and are known by various names, such as tallow, suet, lard, butter, and fat.

Laurel fat is obtained from laurel berries by boiling and pressure. It is green and soft, and is used for salves.

Butter of Cacao, from the beans of *Theobroma cacao*, is white, solid, and rather brittle. It does not become rancid; the greater part of it is a crystalline compound of oleine and stearine, melting at 85°.

Butter of Nutmegs, from the nuts of *Myristica moschata*, is solid, yellow, and possessed of the aromatic smell of the essential oil of nutmegs. Cold alcohol dissolves a fat oil, the essential oil, and the colouring matter; leaving 25 to 30 p. c. of a white crystalline fat, fusible at 87°. This fat resists the action of diluted alkalies, but is quickly saponified by fusion with hydrate of potash. The soap thus formed yields a crystallizable acid, fusible at 122°. This is sericic acid; and the fat is sericate of oxide of glycerule, or sericine. (Playfair.)

Butter of Cocoa-nuts, from the fruit of *Cocos nucifera*, is white and soft, fusible at 68°, and consists of two oils, one liquid, the other solid, at ordinary temperatures. The latter, according to Pelouze and Boudet, is identical with *elaidine.* This butter soon becomes rancid.

Palm oil or butter, from the rind of the fruit of *Avoira elais*, *Elais Guianensis*, is yellow and semi-solid, with a smell of violets. When new, it melts at 81°; when long kept, at 90° to 96°. It easily becomes rancid, glycerine being set free, and at the same time the fatty acids. It contains oleine, margarine? and about two-thirds of its weight of a white solid fat, which is palmitine, and which contains palmitic acid. (Fremy, Stenhouse.) Palm oil is much used for making soap. If white soap is desired, the oil must be bleached; which may be done either by exposure to the sun, by sulphuric acid, or by chlorine. Tallow is added to increase the firmness of the soap. For yellow soap, resin is added to the palm oil.

Galam butter, from *Bassia butyracea*, is often confounded with palm oil. It is softer and more fusible, and is equally liable to rancidity.

There are some other kinds of vegetable butter, which, however, are too little known to be accurately described.

Tallow.—This name is given to the fat of oxen, sheep, deer, and goats. They all consist chiefly of stearine with a little oleine; but the last-named contains also hircine (hircate of oxide of glycerule) in small quantity, to which it owes its peculiar smell. They form, with soda, firm hard soaps; and are much used, not only for soap-making, but for ointments and plasters, and in making candles. Tallow soon becomes rancid on exposure to the air. The fat of *ox-marrow*, having very little tendency to rancidity, is used for salves and pomatums.

Butter, derived from the milk of the cow, is a soft yellowish fat, which may be purified from buttermilk, cheese, and the other impurities it contains, by melting it; when the water subsides, and the pure oil rises to the surface. It should be repeatedly melted with water. It consists of margarine, oleine, butyrine, caprone, and caprine. The three latter are compounds of oxide of glycerule with the volatile butyric, caproic, and capric acids. (Chevreul.) Their quantity is small, but to them are owing the peculiar pleasant taste and smell of fresh butter. Butter soon becomes rancid: hence the necessity of either procuring it always fresh, or of salting it. When purified as above, it keeps much longer, but is much less pleasant to the taste. If melted butter be poured into ice-cold water, it assumes the consistence of fresh butter.

Rancid butter, like other rancid fats, may be in a great measure deprived of rancidity by melting and shaking it repeatedly with twice its weight of boiling water. Fresh butter, when laid in syrup, keeps even better than salted butter.

Hog's-lard, or *Axunge*, is softer than tallow. It contains more oleine, and probably margarine along with the stearine, or in place of it. It is chiefly used for ointments.

Human fat appears to contain no stearine, but only margarine and oleine.

Spermaceti.—This remarkable fat is found in certain cavernous receptacles in the head of several species of *Physeter* and *Delphinus.* During the life of the animal, it is dissolved in spermaceti oil; but, after death, it is deposited on cooling in a crystalline mass. It consists chiefly of cetine, which is contaminated with an oil soluble in cold alcohol.

Cetine. — To obtain it pure, spermaceti is dissolved in boiling alcohol, which on cooling deposits the cetine in crystals. The process is repeated as long as the alcohol extracts any oil. Pure cetine is crystalline, has a bright pearly lustre, and melts at 120°. At 670° it sublimes undecomposed. If distilled at a higher temperature, it yields inflammable gas, a mixture of margaric and oleic acids, and an oil insoluble in alkalies, but no ethal (hydrated oxide of cetule).

When saponified by fusion with caustic potash, it yields oleate and margarate of potash, and ethal; the latter amounting to 40·64 p. c. According to Dumas, cetine contains 2 at. of margaric acid, 1 at. of oleic acid, and 3 at. of oxide of cetule ($C_{32}H_{33}O$). But as margaric and oleic acids, in the above proportions, and adopting the formula of Chevreul, neutralize 4 atoms of base, while only 3 atoms are here present, it is probable that 1 at. of basic water should be added to the formula of Dumas. Moreover, it has not been proved satisfactorily that the acids in cetine are identical with common margaric and oleic acids; so that the formula of cetine must be considered as doubtful.

Cholesterine or *Fat of Bile.* — This fat is found in the blood, the brain, and the bile of animals. It is the chief ingredient of biliary concretions, from which it is readily obtained by solution in boiling alcohol, which on cooling deposits the cholesterine, retaining in solution the small portion of colouring matter which it dissolves. Any fatty acids which may contaminate it are easily removed by potash.

It forms large pearly or silvery scales, insoluble in water, fusible at 279°, and volatilizable in close vessels, without change. It is not saponified nor dissolved by caustic alkalies; and it appears to be dissolved in the serum of the blood by means of soap, stearate of soda being present in that fluid. Wagner has shown that 4 parts of soap, dissolved in water, take up one part of cholesterine.

The analyses of cholesterine, by Chevreul, Couerbe, and Marchand, indicate either the formula $C_{38}H_{33}O$ or $C_{36}H_{32}O$. A knowledge of its atomic weight can alone decide between these formulæ.

Cholesteric Acid.—By boiling with nitric acid, cholesterine is converted into cholesteric acid. This acid forms pale yellow needles, lighter than water, very soluble in ether. It forms red salts; those with the alkalies are soluble, the rest insoluble. Its formula is unknown, but it contains nitrogen, derived from the nitric acid. (Pelletier and Caventou.)

Ambreine. — This is a substance closely allied to cholesterine. It occurs in ambergrise, a peculiar fat found floating on the sea in the southern latitudes, and supposed to be a concretion formed in the stomach of the spermaceti whale. From ambergrise ambreine is obtained, exactly as cholesterine is from biliary calculi. By the action of nitric acid it is converted into an acid, *ambreic* *acid*, analogous to cholesteric acid, and, like it, containing nitrogen.

Castorine.—This is a crystallizable substance, analogous to the two preceding; which is extracted, along with common fat, from castor (castoreum) by the action of alcohol. It dissolves unchanged in alkalies, and is converted by nitric acid into an acid analogous to ambreic acid. (Brandes.)

WAX.

This substance, or a substance closely resembling it, is found in many plants, particularly in the pollen. It is collected by bees to build their combs; but it is not determined whether these animals possess the power of producing it from sugar, or any other portion of their food.

As obtained by melting honeycomb with water, it is yellow, and has a peculiar smell. It melts at 145°. When exposed in thin layers, or ribbons, to the action of light, it is bleached, and deprived of smell. When bleached, it melts at 158°, and congeals at 149°.

According to the researches of Gay-Lussac and Thenard, Chevreul, Saussure, Ettling, and others, wax is a mixture of two substances in very variable proportions. One of these is very soluble in hot alcohol, the other very sparingly soluble in that menstruum. The former is cerine, the latter myricine.

Cerine is deposited in a gelatinous mass, composed of fine needles, from the alcohol on cooling. When boiled with potash, it is partially saponified, and the soap appears to contain margaric and oleic acids. There is obtained at the same time about 56 p. c. of a neutral substance; insoluble, or nearly so, in alcohol, and unchanged by boiling with potash. This is *ceraine.* It seems to have the same composition as the portion of wax insoluble in alcohol.

Myricine.—This is the matter left undissolved when wax is boiled with alcohol. It requires 200 parts of boiling alcohol for solution, and is not affected by boiling with caustic potash.

The formulæ of these compounds are not ascertained; but the analyses of Ettling and Hess show that cerine contains more oxygen than myricine; while the composition of ceraine and myricine appears to be the same.

Some species of vegetable wax appear to be composed of myricine alone, others of cerine; while the so-called wax of *Myrica cerifera*, when saponified, yields stearic, margaric, and oleic acids, along with glycerine, and is therefore rather fat than wax. Bees' wax varies very much in the proportions of myricine and cerine which it contains.

When wax is distilled, it yields a fatty acid, not yet examined; an oil composed of carbon and hydrogen in the same proportions as olefiant gas; and a solid white crystallizable substance of similar composition, which is identical with paraffine. Neither sebacic acid nor acroleine appears among the products.

Japan or *Tree Wax*, from the fruit of ***Rhus succedanea***, resembles wax in appearance, but appears to be more of the nature of fat. It is easily saponified, and yields an acid which is either margaric acid, or one analogous to it. Substances more or less similar to wax are obtained also from ***Croton sebiferum***, ***Celastrus ceriferus***, and ***Ceroxylon andicola***. They are as yet little known.

Cerosine. — Some species of sugar-cane yield on the surface of the cane a waxlike substance, which has been examined by Dumas, who has given to it the above name. It forms fine light pearly scales, fusible at 180°, and is not saponified by potash. The analysis of it by Dumas led him to the formula $C_{48}H_{50}O_2$.

APPENDIX.

ORGANIC ACIDS, HITHERTO LITTLE EXAMINED.

Chelidonic Acid.—This acid was discovered by Probst in *Chelidonium majus*. It forms small white crystals, very acid to the taste, sparingly soluble in cold water, soluble in 26 parts of boiling water. The analysis made by Probst leads to the formula $C_7H_2O_3$, which seems to indicate some relation to meconic acid, which occurs in the same natural family of plants, the Papaveraceæ.

Caincic Acid. — This acid occurs in the root of several species of *Chinococca*. Formula, $C_8H_7O_4$? (Liebig.) It is crystallizable, and has at first little taste, but soon developes an acrid bitterness. It is sparingly soluble in water and ether, more soluble in alcohol.

Crameric Acid.—This acid is found in rhatany root, said to be the root of *Crameria triandra;* but some commercial specimens do not yield it. It is crystallizable, soluble in water, and has a sour astringent taste. It is remarkable for its strong affinity to baryta. It is even capable of depriving sulphate of baryta of that earth; and the cramerate of baryta is not decomposed, either by sulphuric acid, or by soluble sulphates. Its composition is unknown.

Caffeic and *Tanno-caffeic Acids* were discovered by Runge in coffee. The former is a white powder, which when heated yields the aromatic odour of roasted coffee. The latter is a variety of tannic acid, producing in salts of iron a green precipitate.

Boletic Acid. — Discovered by Braconnot in the fungus *Boletus pseudo-igniarius.* It is crystallizable and volatile, and precipitates peroxide of iron completely from its solution.

Fungic Acid occurs, according to Braconnot, in most fungi. It does not crystallize, is deliquescent, and has a very sour taste.

There are several other acids, the existence of which as distinct compounds is still problematical: such are, Tanacetic Acid, in *Tanacetum vulgare;* Lactucic Acid, in *Lactuca virosa;* Atropic Acid, in *Atropa belladonna;* Cocognidic Acid, in the seeds of *Daphne gnidium;* Solanic Acid, in the different species of *Solanum;* Coneic Acid, in *Conium maculatum;* Aceric Acid, in *Acer campestre;* *Moroxylic Acid*, in the wood of the Mulberry; Kinovic Acid, in the Chinanova Bark; Menispermic Acid, in Cocculus Indicus, which is the seed of *Menispermum Cocculus*,—an acid said to exist in the silkworm; &c. &c. It is probable that most of these acids, when properly investigated, will be found identical with some one or other of the acids previously described.

OF THE VOLATILE OR ESSENTIAL OILS.

Many vegetable products, when distilled with water, yield essential or volatile oils, which are liquids, more or less volatile, sparingly soluble in water, generally colourless, although occasionally having a peculiar tint, and for the most part possessing the entire odour of the plant. They are inflammable, burning with a bright but smoky flame, and undergo peculiar changes by the action of air and water.

Analogous to these are the so-called empyreumatic oils, which are among the products of the destructive distillation of organic matter.

Many of the essential oils exist ready formed, and in the free state, in certain parts of plants; as, for example, in the rind of the orange and lemon, from which they may be obtained by mere pressure. Others flow from incisions in the plant, combined with resin, forming what are called Balsams; as is the case with oil of turpentine. In several cases it has been proved, that the oils are first formed by the mutual action of two or more organic compounds when the plant is placed in contact with water: this is the case with the oil of bitter almonds, and with oil of mustard, and is true of all the volatile odoriferous oily matters formed during fermentation or putrefaction. (See ante, Amygdaline.)

It thus happens that perfectly inodorous plants, as, for example, *Centaurium minus*, when allowed to ferment with water, and then distilled, yield a penetrating essential oil.

The essential oil of *Spiræa ulmaria* may be obtained, with all its characteristic properties, from salicine, by the use of oxidizing agents (see Hyduret of salicule); and finally, when starch or sawdust and similar substances are heated with sulphuric acid, peroxide of manganese, and water, they yield, besides formic and carbonic acids, oily liquids possessing all the characters of essential oils.

In some fragrant flowers, as the lime blossom, jonquil, and jasmine, the odorous principle may be extracted by ether or by fixed oil, but cannot be obtained by distillation with water; either because it is decomposed, or else is so soluble that it cannot be separated readily from the water. In the latter case, it may sometimes be separated by saturating the water with common salt.

Many essential oils contain a crystalline substance dissolved, to which the name of Stearopténe is given. This in numerous cases, as in the oils of lavender and valerian, is pure camphor. Others contain volatile oily acids mixed with a neutral oil, as is the case in oil of cloves; and many contain nitrogenized compounds, such as ammonia and hydrocyanic acid.

Their specific gravity varies; some are heavier, others lighter than water.

Some contain no oxygen; while in others that element is present. It is worthy of especial notice, that all the non-oxygenated essential oils as yet accurately analyzed contain carbon and hydrogen in the same relative proportions, expressed by the empirical formula $C_{10}H_8$. With widely different properties, they yield the same result, as to these elements, in 100 parts. There can be no doubt that in many cases the true formula is a multiple or submultiple of the above. In others, the arrangement of the same number of equivalents may vary.

The oxygenated essential oils are commonly mixtures of several, differing in volatility; but, as no one has succeeded as yet in effecting their complete separation in any case, the analyses of them which have been made are of no value.

All essential oils are miscible with alcohol; and they are more soluble in weak spirits, the more oxygen they contain. To water, although sparingly dissolved by that liquid, they give their peculiar odour, forming what are called *distilled waters*. When these are made by distilling the plant with water, they are apt to mould, from the presence of foreign matter; but, if distilled a second time, they keep well in close vessels.

It must here be observed, that the odour of these oils is closely related to their alteration by air and water. They almost all absorb oxygen, and those which do so most rapidly have the strongest smell. If non-oxygenated oils be distilled with quicklime in vacuo, or in an atmosphere of carbonic acid, the product is absolutely inodorous; and it is impossible in this state to discriminate oil of lemons from oil of turpentine or of juniper: but, when exposed to the air, they quickly become odorous, while they absorb oxygen, becoming viscid and resinous. It would appear, therefore, as if the odour accompanied the act of oxidation, as is the case with metallic arsenic. By long exposure to the air, these oils gradually acquire the aspect of resins. Many become acid which before were neutral: the acid in oil of cinnamon is cinnamic acid; in oil of bitter almonds it is benzoic acid; and, according to Bizio, in some cases it is acetic acid. It is probable that the resins formed by the oxidation of essential oils are identical with those which in the balsams accompany the oils; but on this point we have no experiments. According to Saussure, carbonic acid is one of the products of the action of the atmosphere on essential oils.

It is not probable that these oils act as radicals, combining with oxygen directly to form the resins; it seems more likely that the oxygen removes one portion of their hydrogen, while the remainder of the hydrogen resists the action of oxygen, chlorine, and iodine much more strongly.

All the non-oxygenated oils, in contact with iodine, yield a part of their hydrogen with a kind of explosion, while iodine replaces the hydrogen thus removed. The new compound, although rich in hydrogen, does not yield any more to an additional quantity of iodine. The action of both oxygen and chlorine is analogous: both remove a part of the hydrogen; both also enter into the new compound, replacing that element; so that the new body, the resin, for example, always contains less hydrogen than the oil.

By strong nitric acid the essential oils are converted into resinous matters, as yet little studied. Many oils burst into flame when mixed with nitric acid, especially if a little sulphuric acid be previously added to it. When boiled with moderately strong nitric acid till dissolution ensues, the oils yield peculiar crystallizable acids, but no oxalic acid.

The essential oils dissolve sulphur and phosphorus, and are miscible with bisulphuret of carbon and hydrated acetic acid.

We shall now briefly describe the individual oils, and their relation to other substances. The whole subject is but imperfectly known; and a profound and searching investigation is required, not only of their composition, but also and chiefly of the changes they undergo by the action of oxygen, chlorine, iodine, &c. before we can hope to acquire a knowledge of their true nature and constitution. Oil of turpentine and oil of lemons, for example, are both composed according to the empirical formula $C_{10}H_8$. The latter may be $C_{10}H_7 + H$; the former $C_{20}H_{15} + H$. It is obvious that the decision of these and similar questions cannot be expected from mere analyses of the oils, however accurate.

1. NON-OXYGENATED ESSENTIAL OILS.

Oil of Turpentine.—Turpentine, which is a semi-fluid mass, flowing from incisions in the wood of many species of Pinus, and which is a good type of the balsams, yields the oil in question when distilled with water. The oil of commerce, from exposure to the air, is always contaminated with resin. To purify it, it is again distilled with water, dried by chloride of calcium, and rectified. It is then clear, colourless, very mobile, and has a very pungent peculiar smell and a burning taste. It sp. g. is 0·86 to 0·87. When pure, it is neutral to test paper. It boils at 312°, and the density of its vapour is 4·764. (Dumas.) It is almost insoluble in water, but communicates to that liquid its smell. When moist, and left long in the cold, it often yields a solid crystalline hydrate, in which to $C_{10}H_8$ there are 2 at. water, (Blanchet and Sell,) or 3 at. (Dumas and Peligot.) This hydrate is soluble in 22 parts of hot water, and crystallizes on cooling. The oil is very soluble in alcohol, ether, and fixed oils. Being less soluble in weak spirits, it may be freed from resin by agitation with a little proof spirit. It is instantly decomposed by sulphuric or nitric acid, and takes fire with a mixture of the two. Chlorine also acts on it rapidly, and with flame, if the quantity of oil be small in proportion to the gas. By the slow action of chlorine, one fourth of the hydrogen is removed, and replaced by chlorine ; and a similar effect is produced by bromine and iodine. It dissolves sulphur and phosphorus.

Pure oil of turpentine contains no oxygen. In 100 parts it is composed of

Carbon	88·46
Hydrogen	11·54

which corresponds to the formula $C_{10}H_8$.

With hydrochloric acid gas it forms a liquid and a solid compound. The former is volatilizable, colourless, soluble in alcohol and ether. The vapour of this compound, passed over hot lime, yields chloride of calcium and an oil of the same composition as oil of turpentine. This has been called Peucyl, or Peucylene. Its sp. g. is 0·86, and it boils at 273°.

The solid compound may be purified by sublimation and crystallization from alcohol. It is white, translucent, lighter than water, insoluble in water, soluble in alcohol. Its solution does not precipitate nitrate of silver.

Its empirical formula is $C_{20}H_{17}Cl$. By repeated distillation of its alcoholic solution over hydrate of lime, the hydrochloric acid is at last removed ; and it yields another oil of the composition of oil of turpentine, called Dadyl, Terebene, or Camphilene. Its sp. g. is 0·86, and it boils about 300°. According to Dumas, who considers it to be pure oil of turpentine, and calls it Camphene, its true formula is $C_{20}H_{16}$, as deduced from the action of chlorine upon it. The results of Soubeiran and Capitaine, and of Deville, confirm this view.

The last-mentioned oil, when brought in contact with hydrochloric acid gas, reproduces the crystalline compound above-mentioned which has long been known as Artificial Camphor. According to Blanchet and Sell, oil of turpentine is a mixture of two oils, Peucyl and Dadyl, which have the same composition, and of which the former gives with hydrochloric acid a liquid, the latter a solid compound.

By the action of nitric acid, oil of turpentine is first converted into a resinous mass, which by long boiling with the acid is at last dissolved, and converted into a crystalline acid, Turpentinic Acid. According to Bromeis, its formula is $C_{14}H_9O_7,HO$. It merits a careful investigation.

Oil of turpentine is used in medicine both internally and externally. It is also much used in the arts for dissolving resins and oils in making varnishes.

Oil of Juniper.—Obtained from the berries of *Juniperus communis* by distillation with water. The unripe berries yield most oil; and this oil is a mixture of two, differing in volatility, as one boils at 310°, and the other at 400°. Both have the odour of juniper; and both, when agitated with a solution of salt, form crystalline hydrates. The more volatile portion has the same composition in 100 parts as oil of turpentine, and forms with hydrochloric acid gas a liquid compound, the formula of which appears to be $C_{15}H_{13}Cl$, according to Souberian and Capitaine, who call the supposed radical of this compound Juniperiléne.

The addition of a little oil of juniper to brandy forms gin, or geneva. Both this and the oil are used as diuretics, and give to the urine the smell of violets.

Oil of Sabine, from the berries of *Juniperus Sabina*, resembles the preceding, has the same composition, and is also used as a diuretic. Its smell, however, is disagreeable.

Oil of Elemi, from the resin of *Amyris elemifera* and *A. ceylanica*, is colourless, has a pleasant smell, the sp. g. 0·852, and boils at 330°. Its other properties resemble those of oil of turpentine, except that it does not produce artificial camphor with hydrochloric acid gas, which colours it brown. It has the composition of oil of turpentine; and its formula is C_5H_4, or a multiple of this.

Oil of Storax, obtained from *Storax liquida* by distillation with water, is colourless, and has the smell of the balsam. According to Marchand, it has the same composition as benzine, C_2H, or some multiple of it.

Nitric acid, by the aid of heat, converts it into a resinous mass, which, when distilled with water, yields a pungent oil with an odour of cinnamon, which crystallizes on cooling, and by solution in hot alcohol may be obtained in fine crystals. (Simon.) This is Nitrostyrole. Its formation is accompanied by that of benzoic and hydrocyanic acids.

The oil of storax itself, called by Simon Styrole, when exposed to the air, absorbs oxygen, and is slowly converted into a gelatinous mass, insoluble in alcohol, ether, and oil of turpentine, and no longer volatile without decomposition. Simon calls this *Oxide of Styrole.* It does not yield with nitric acid the same products as the styrole itself.

This oil is evidently a remarkable compound; and, as it differs in composition from all the other non-oxygenated oils, it merits a careful study.

Oil of Lemons, obtained by pressure from the peel of the fruit of *Citrus medica*, is generally yellowish, and slightly turbid. When purified by rectification, it is clear, colourless, has a strong and pleasant smell of lemons, and a hot pungent taste. It has a sp. g. of from 0·848 to 0·85 and higher, and boils from 330° to 353°, being a mixture of two oils which may be separated by distillation to a certain extent. The more volatile portion is also the lighter of the two. Reagents act on it very much as on oil of turpentine; and, like that oil, it forms with hydrochloric acid gas a solid and a liquid compound, which both have exactly the same composition, but contain for the same amount of carbon and hydrogen twice as much hydrochloric acid as the corresponding compounds of oil of turpentine. When deprived of the hydrochloric acid by quicklime, they yield two oils of the same composition: one of which, Citréne, has the sp. g. 0·847, and boils at 330°; the other, Citriléne, has the sp. g. 0·88, and boils at 345° to 353°. It is the former, Citréne, that yields the solid compound with hydrochloric acid. (Blanchet and Sell, Soubeiran and Capitaine, Dumas.)

Both oil of lemons and the two oils last described have the composition, in 100 parts, of oil of turpentine; and the formula $C_{10}H_8$, or more probably C_5H_4. The crystalline compound with hydrochloric acid seems to be $C_{10}H_9Cl$.

The oils of Cedro, and Cedrat, are probably identical, when pure, with oil of lemons.

Oil of Oranges, from orange peel, *Citrus aurantium*, differs only in smell from oil of lemons. Its composition and its actions with regeants are precisely the same.

Oil of Neroli, or of orange-flower, is quite distinct from the above oils, which are derived from the fruit. It has the peculiar fragrance of the flowers, and is in great part soluble in water; it is soon reddened by the action of air and light. Orange-flower water is a solution of this oil, obtained by distilling the flowers with water. Oil of neroli appears to contain a stearopténe, possibly a hydrate. The composition of the oil is not exactly known, and it is doubtful whether it contain oxygen or not.

Oil of Copaiva, obtained by distilling balsam of copaiva (from *Copaifera multijuga*) with water, is colourless, has the sp. g. 0·91, and boils at 473°. It is soluble in 2½ parts of absolute alcohol; but requires 25 to 30 parts of alcohol, sp. g. 0·85, for solution. Reagents act on it as on oil of turpentine. Nitric acid causes a kind of explosion; producing a crystalline compound, at first yellow, then blue, and finally becoming green. With hydrochloric acid it forms a crystalline compound, having the composition of that from oil of lemons, $C_{10}H_9Cl$; it also forms a liquid compound: but the radicals of these could not be isolated. (Soubeiran and Capitaine, Blanchet.) The oil of copaiva has the same composition as oil of turpentine. It is used in medicine.

Oil of Pepper, from *Piper nigrum*, has similar properties and the same composition; but it does not form a crystalline compound with hydrochloric acid, which it absorbs in large quantity.

Oil of Cubebs, from the fruit of *Piper cubeba*, is colourless and aromatic, sp. g. 0·929, boils at about 490°. It gives a crystalline compound with hydrochloric acid, which seems to be $C_{15}H_{13}Cl$. The oil is supposed by Soubeiran and Capitaine to be $C_{15}H_{12}$, which is still the same in 100 parts as oil of turpentine.

OXYGENATED ESSENTIAL OILS.

Oil of Bitter Almonds, obtained by distilling with water the bruised almonds after the fixed oil has been expressed, is yellow, and has a pleasant smell and a hot taste. It is a mixture of hyduret of benzule with hydrocyanic acid, both formed by the mutual action of amygdaline, emulsine or synaptase, and water. It is very poisonous. (See Benzule and its compounds.)

Oil of Laurel leaves, obtained by distilling the leaves of *Prunus* *laurocerasus* with water, appears to be essentially the same as oil of bitter almonds.

The leaves and kernels of the peach, *Amygdalus persica*, and of *Prunus padus*, as well as other species of Amygdalus and Prunus, yield a similar oil.

Oil of Spiræa. (See Salicule and its compounds.)

Oil of Cinnamon.—Of this oil there are two varieties; Ceylon oil of cinnamon, from *Laurus cinnamomum*, and common oil of cinnamon, from *Laurus cassia.* Both, when fresh, are pale yellow, but become brown on exposure to the air. They have a sweetish pungent aromatic taste, and a pleasant smell. Their sp. g. is from 1·03 to 1·09. (See Cinnamule and its compounds.) According to Mulder, both oils have the same composition, and the formula $C_{20}H_{11}O_2$, when quite fresh. On exposure to the air, they rapidly absorb oxygen; and produce cinnamic acid, two resins, and water. Mulder has analyzed both the resins, which he calls resin alpha and resin beta. The former is soluble in cold alcohol, and its formula is $C_{15}H_{7\frac{1}{2}}O_2$? The latter is insoluble in cold alcohol, and has the formula $C_{12}H_5O$. If we compare the composition of these resins and of cinnamic acid with that of the oil, we find that 3 at. of oil of cinnamon $= C_{60}H_{33}O_6 + 8$ at. oxygen $=$

$$C_{60}H_{33}O_{14}=\left\{\begin{array}{ll}\text{1 at. cinnamic acid} & = C_{18}H_7\,O_3\\ \text{1 at. resin beta} & = C_{12}H_5\,O\\ \text{2 at. resin alpha} & = C_{30}H_{15}O_4\\ \text{6 at. water} & = \underline{\quad\;\; H_6\,O_6.}\\ & \; C_{60}H_{33}O_{14}.\end{array}\right.$$

The 8 atoms of oxygen are derived from the air. Oil of cinnamon is decomposed by hydrochloric acid gas; yielding a volatile oil not yet examined, water, and two resins, one soluble, the other insoluble, in cold alcohol. The formula of the latter is $C_{20}H_8O$; that of the former $C_{14}H_7O$. In like manner, concentrated sulphuric acid acts on the oil, producing two resins, one soluble, the other insoluble, in alcohol. The composition of the

$$\begin{array}{ll}\text{former is} \;\; . \;\; . \;\; . \;\; . \;\; . & C_{30}H_{15}O_2 \text{ or}\\ \text{that of the latter} \;\; . \;\; . \;\; . \;\; . & \underline{C_{30}H_{15}O}\\ \text{Together} \;\; . \;\; . \;\; . \;\; . \;\; . & C_{60}H_{30}O_3 \text{ which is}\end{array}$$

3 at. oil of cinnamon — 3 at. water. The sulphuric acid removes an atom of water from each atom of the oil, and the oxygen of the residue is unequally divided between the resins.

With nitric acid, oil of cinnamon forms a white crystalline compound, $C_{18}H_9NO_7$. The oil $C_{20}H_{11}O_2$ loses here C_2H_2, and takes up NO_5, and the rational formula of the resulting compound is probably $C_{18}H_8O_3 + NO_3 + HO$; which explains its decomposition by contact with water, and the formation of cinnamic acid when it is dissolved in sulphuric acid. With water it yields an oil which is $C_{18}H_8O_2$, that is, hyduret of cinnamule; while its solution in sulphuric acid, when mixed with water, deposits cinnamic acid, $C_{18}H_7O_3$.

Along with the crystalline compound, nitric acid produces a red oil, which is instantly decomposed by water, although not by anhydrous alcohol or ether. With water the red oil yields another oil, the formula of which is $C_{15}H_7O_2$. These results are taken from a very recent memoir by Mulder.

Oil of Cloves.—From the undeveloped buds of *Caryophyllus aromaticus.* Sp. g. 1·055. It is the least volatile of the essential oils, and is a mixture of caryophyllic acid and an indifferent or neutral oil. (See Caryophillic Acid.)

Oil of Sassafras. — From *Laurus Sassafras.* Sp. g. 1·08 to 1·09. It is coloured scarlet by nitric acid, yielding oxalic acid. When long kept, it deposits a stearopténe in large crystals, which melts in the heat of the hand, and is volatile.

Oil of Sweet Bay.—From *Laurus nobilis.* A dirty white, thick oil, with a pungent smell and a bitter taste. Sp. g. 0·914. By distillation it yields a lighter oil, sp. g. 0·857, and one less volatile, sp. 0·885, while a thick mass remains in the retort. The more volatile portion, according to Brandes, has the formula $C_{20}H_{16}O$, which is that of the oil of camphor.

Laurine is a crystalline substance which may be extracted from bay leaves by absolute alcohol. It is fusible and volatile, and seems to be a neutral substance.

Some other oils, little known, are derived from different species of Laurus and Persea, such as *Laurus Pichurim*, *Laurus Culilaban*, &c.

Oil of Saffron. —From the stigmata of *Crocus sativus.* It is yellow, heavier than water, and gradually changes into a white solid, lighter than water. It has the odour of saffron.

Oil of Bergamot.—This oil, from *Citrus Limetta* (the lime), and *Citrus Bergamotta* (the bergamot), has an odour resembling that of oil of lemons, from which, however, it differs in containing oxygen. It is believed to contain a mixture of oils, having the composition of citréne, with a hydrate of such an oil, and an oxygenated oil formed by the action of the atmosphere. It generally deposits a stearopténe, which Ohme calls Bergapténe; the formula of which, according to Ohme and Mulder, is C_3HO. According to Soubeiran and Capitaine, anhydrous phosphoric acid deprives the hydrate of its water, and the oil which separates has the composition of oil of lemons. A part of the oil seems to combine with phosphoric acid, producing an acid analogous to phosphovinic acid. With hydrochloric acid gas, oil of bergamot forms only a liquid compound.

Oil of Roses.—Otto or Attar of Roses, from the petals of *Rosa centifolia, moschata, sempervirens*, and other species. A yellowish thick oil, congealing in the cold to a buttery mass, composed of shining foliaceous crystals. When much diluted, its smell is highly agreeable; when strong, it causes headache. It has a mild aromatic taste, sp. g. 0·832. It consists of a solid (stearopténe), and a liquid oil, in variable proportions. The solid portion, which is insoluble in alcohol, and may be purified by solution in ether, has the formula CH, or some multiple of it.

Oil of Rhodium, from the wood of *Convolvulus scoparius*, has an odour of roses, and is sometimes used to adulterate oil of roses.

Oil of Rose Geranium, from *Pelargonium radula*, has also a similar odour, and is used for the same purpose; but it smells also of *Geranium Robertianum*. It is crystalline, and melts at 68°.

Oil of Cajeput, from *Melaleuca Leucodendron*, and *Melaleuca Cajeputi*. It has commonly a pale green colour. Its odour is unpleasant, except when much diluted, when it resembles that of camphor and rosemary; sp. g. 0·978. The green colour is natural to the oil, but is sometimes increased by the presence of copper, derived from the vessels in which it is kept. Blanchet and Sell found the composition of a very pure specimen to be $C_{10}H_9O$.

The *Oils of Nutmeg* and *Mace*, the former from the nut of *Myristica moschata*, the latter from the rind of the same nut, appear to be identical. They contain a liquid oil and a stearopténe. The latter, according to Mulder, is $C_8H_{16}O_3$.

Oil of Cardamom, from *Amomum repens*, belongs to this class of oils, but has not been minutely studied. It is aromatic, and its sp. g. is 0·945.

The *Stearopténe of the Tonka bean*, the fruit of *Dipterix odorata*, has a pleasant aromatic odour, is heavier than water, soluble in alcohol and ether.

Oil of Anise, from *Pimpinella anisum*, is solid at temperatures below 50°, owing to the crystallization of a stearopténe which it contains in large quantity. The solid portion, according to Cahours, has the formula $C_{22}H_{13}O_2$. With chlorine it forms a liquid compound, $C_{22}H_{10}Cl_3O_2$; with diluted nitric acid it yields a new acid, the compound of which with oxide of silver is $C_{16}H_6O_5$, AgO; and with fuming nitric acid another, the silver salt of which is $C_{16}H_5(NO_4)O_5$,AgO. Fused with hydrate of potash, it yields an acid, not further investigated. It also forms with sulphuric acid a solid compound; and with fuming sulphuric acid another new acid, which yields a soluble salt with baryta.

Oil of Dill, from *Anethum* or *Apium graveolens*, has the strong smell of the plant, and a sweetish burning taste; sp. g. 0·881.

Oil of Fennel, from *Anethum fœniculum*, has the odour of fennel, and the sp. g. 0·997. It contains a stearopténe, which seems to be the same as that of oil of anise. The difference between the two oils depends on the liquid portion.

The *Oil of Water Fennel*, from *Phellandrius aquaticus*, appears to contain ammonia, and is poisonous.

Oil of Parsley, from *Apium petroselinum*, has a strong smell of parsley, and contains a liquid and a solid portion. The former appears to have the composition of oil of turpentine; the latter is said by Loewig and Weidmann to be $C_{12}H_8O_3$.

Oil of Carraway, from *Carum carui*, appears to contain two oils differing in volatility. The more volatile seems to contain no oxygen; the other appears to be analogous to *oil of cumine.* (See Cuminic Acid.) The latter is derived from *Cuminum cyminum.*

Oil of Coriander, from *Coriandrum sativum*, has the smell of the seeds, and the very low sp. g. of 0·759.

Oil of Pimpernel, from *Pimpinella saxifraga*, has a golden yellow colour, an unpleasant smell of parsley, and is lighter than water. That from *P. magna* is at first blue, then green.

Oil of Peppermint, from *Mentha piperita*, has commonly a pale yellow or green colour, and a pungent cooling taste. Its sp. g. is 0·902 to 0·91. The American oil contains a stearopténe, which appears to be $C_{10}H_{10}O$. (Dumas, Blanchet and Sell.) According to Walter, this should be doubled, $C_{20}H_{20}O_2$; and by the action of anhydrous phosphoric or sulphuric acid 2 at. of water are removed, and a carbo-hydrogen is left $= C_{20}H_{18}$, which Walter calls Menthene: so that the rational formula of the stearopténe is $C_{20}H_{18}$,

$2HO$, or possibly $C_{20}H_{19}O,HO$. Treated with chloride of phosphorus, the stearoptène yields chloride of menthene $= C_{20}H_{17}Cl$. Chlorine gas produces two other compounds containing chlorine.

By the action of nitric acid, menthene yields a compound, $C_{10}H_9O_9$; and by the action of chlorine it is converted into another compound, $C_{20}H_{13}O_5$. (Walter.)

Oil of Pennyroyal, from *Mentha pulegium*, has, according to Kane, the formula $C_{10}H_8O$; which is remarkable, as being identical with that of camphor.

The *Oil of Mentha viridis*, according to Kane, is $C_{35}H_{28}O$.

Oil of Marjoram, from *Origanum majorana*, contains a stearoptène, which, according to Mulder, is $C_{14}H_{15}O_5$. The oils of Origanum Smyrnæum and of Origanum vulgare are similar, and are used to adulterate the oil of marjoram. According to Kane, the latter is $C_{50}H_{40}O$.

Oil of Lavender, from *Lavandula spica*, has the odour of the plant, the sp. g. 0·872, and boils at 365°. It contains a variable quantity of stearoptène, which, according to Dumas, is camphor.

Oil of Rosemary, from *Rosmarinus officinalis*, according to Kane is $C_{40}H_{36} + 2HO$. Sulphuric acid blackens it, and causes the separation of an oil, having an alliaceous smell, and the composition of oil of turpentine. Kane calls this oil Rosmarine.

Oil of Basil, from *Ocimum basilicum*, contains a stearoptène, which Dumas and Péligot found to be $C_{20}H_{16} + 6HO$, agreeing in composition with the hydrate of oil of turpentine. The liquid portion has not been examined.

Oil of Thyme, from *Thymus vulgaris*, has the odour of the plant, and deposits a stearoptène when kept.

Oil of Valerian, from *Valeriana officinalis*, contains valerianic acid (see that acid) and a stearoptène.

Oil of Rue, from *Ruta graveolens*, is yellow or greenish, has the sp. g. 0·837, and boils at a temperature from 425° to 473°. According to Will, its composition is $C_{28}H_{28}O_3$, and the density of its vapour, $= 7{\cdot}69$, agrees with this formula.

Oil of Cascarilla, from the bark of *Croton eleutherium*, is sometimes yellow, at other times blue or green; has the sp. g. 0·938; and contains two oils, one boiling at 344°, the other less volatile. According to Völckel, the former contains no oxygen, and has probably the usual composition of non-oxygenated essential oils. The latter contains oxygen.

Oil of Chamomile, from *Matricaria chamomilla*, is dark blue, viscid, and has a bitter aromatic taste; sp. g. 0·924. Nitric acid decomposes it, and the addition of water to the acid solution precipitates a resin having the odour of musk. It dissolves iodine without producing heat, unless when adulterated with oil of turpentine or of lemons, when the violent action of iodine on these oils discovers the adulteration. The Roman oil of chamomile, from *Anthemis nobilis*, is very similar to the above.

Oil of Wormwood, from *Artemisia absinthium*, is greenish yellow, has an unpleasant bitter taste, and the sp. g. 0·897.

Oil of Tea, from *Thea viridis*, is yellow, and readily solidified by cold. It has the odour of tea in so high a degree that it is apt to cause stupefaction when smelt. In the process of drying the tea leaves, the greater part of the oil is lost, so that the best Hyson yields hardly 1 p. c. of the oil.

The following vegetables yield oxygenated essential oils, of which however so little is known, that for the present we merely give the catalogue of the names. Many of them contain stearopténe or solid volatile oils.

Teucrium marum, Hyssopus officinalis, Salvia officinalis, Lycopus europæus, Ledum palustre, Achillea millefolium, Artemisia contra, Artemisia dracunculus, Artemisia vulgaris, Tanacetum vulgare, Juniperus lycia and thurifera, Balsamodendron myrrha, Galbanum officinale, Ferula persica, Cupressus sempervirens, Thuja occidentalis, Aristolochia serpentaria, Cæsalpina crista, Hedwigia balsamifera, Betula alba, Wintera aromatica, Populus nigra, Chenopodium ambrosioides, Dahlia pinnata, Parmelia parietina, Tilia europæa, Sambucus nigra, Reseda odorata, Philadelphus coronarius, Jasminum officinale, Syringa vulgaris, Convallaria majalis, Diosma crenata, Myrica gale, and others.

ESSENTIAL OILS CONTAINING SULPHUR.

Several essential oils contain sulphur; and, like all organic compounds in which sulphur is present in any form but that of its compounds with oxygen, they have generally a fetid smell.

Oil of Mustard is obtained from the seeds of *Sinapis nigra*, exactly as oil of bitter almonds from that fruit. The seeds, deprived of fixed oil by pressure, are made into a paste with water, and this after some hours is distilled. The oil is not ready formed in the seed, but is produced by the mutual action of substances contained in them along with water.

Oil of mustard has the sp. g. 1·038, is very pungent to the taste and smell. It contains sulphur and nitrogen, formula $C_8H_5NS_2$; when heated with potash it yields ammonia, sulphuret of potassium, and sulphocyanide of potassium. With ammonia it yields a white crystalline compound, which appears to be composed of $C_8H_8N_2S_2$, or $C_8H_5NS_2 + NH_3$. The nature of this curious compound is still doubtful.

Both black and white mustard, according to Bussy, contain a substance analogous to emulsine or synaptase, called by him Myrosine; and an acid, Myronic acid, which, by the contact of myrosine and water, yields the oil of mustard with other products not yet investigated. Myronic acid occurs in the seeds combined with potash, and the myronate of potash is the substance described by Henry and Garot as Sulphosinapine. It is remarkable that white mustard, although containing myrosine, which is identical with that of black mustard, and apparently also myronic acid, does not yield with water the oil of mustard, but another pungent oil. But the myrosine of white mustard, when added to the residue of black mustard deprived of its myrosine, yields the oil, just as the emulsine of sweet almonds acts on the amygdaline of bitter almonds.

By the action of hydrated oxide of lead, with the aid of a gentle heat, oil of mustard is deprived of all its sulphur; the mixture, distilled with water, yields an ammoniacal liquid, and along with the sulphuret of lead there is found a crystalline substance, called by Simon *Sinapoline.* Its formula appears to be $C_{28}H_{24}N_4O_4$.

It is obvious that the white mustard must contain a substance differing from myronic acid, else it would yield the same oil as black mustard; but this point is still very obscure, and Bussy has not yet published his analysis of myronic acid, which contains carbon, hydrogen, nitrogen, oxygen, and sulphur. It forms salts which have a bitter taste, and no smell. These salts, as well as the acid itself, when distilled with myrosine and water, yield the volatile oil. Some of them are crystallisable.

Besides myronic acid, and myrosine, black mustard may be made to yield a neutral crystalline body, discovered by Simon, who calls it Sinapisine. It is obtained by digesting the seeds in strong alcohol, and acting on the alcoholic extract with ether. Its properties resemble those of the unsaponifiable crystalline fats. If the seeds, after the action of the alcohol, be digested with carbonate of soda, and the solution distilled with an excess of sulphuric acid, there is obtained a volatile acid, not unlike acetic or formic acid. Its salts are extremely soluble, and difficultly crystallizable. Both these compounds require a minute investigation, and the same may be said of the whole subject of the mustard-seed and its volatile oil.

Oil of Horseradish, from *Cochlearia armoracia* and *C. officinalis*, has a very pungent taste and strong smell. It contains sulphur, and causes blisters when applied to the skin.

Oil of Garlic, from *Allium sativum*, has the smell of the plant, and smarts the skin when applied to it.

The onion, *Allium cepa*, yields a similar oil.

Oil of Assafetida, from *Ferula assafetida*, has a still more offensive smell, and a taste at first mild, afterwards acrid. When rubbed with mercury it forms sulphuret of mercury.

The oils of water-pepper, *Polygonum hydropiper* and of *Arum maculatum*, also belong to this class; as do those of *Lepidium latifolium*, and of hops, *Humulus lupulus*.

APPENDIX TO THE ESSENTIAL OILS.

It is proper to mention here several substances which resemble the stearoptènes in so far as they are volatile, with few exceptions crystalline, and may be distilled along with the vapour of water.

Helenine, from *Inula Helenium*, may be obtained by acting on the fresh root with hot alcohol, or by distilling it with water. It crystallizes in white prisms, soluble in alcohol, ether, and essential oils, but insoluble in water. It melts at 162°, and boils about 530°. According to Dumas, its formula is $C_{14}H_9O_2$; according to Gerhardt, it is $C_{15}H_{10}O_2$. When helenine is heated with nitric acid till the product is entirely soluble in ammonia, and the solution mixed with water, there is precipitated a peculiar substance, nitro-helenine, which appears to be $C_{15}H_9O_2 + NO_4$. (Gerhardt.) With chlorine it yields chloride of helenine, $C_{15}H_{10}O_2 + Cl_2$; and Gerhardt obtained another substance, apparently a compound of this last with hydrochloric acid. Both are yellow powders. The latter, heated with quicklime, yields naphthaline. With anhydrous phosphoric acid, helenine yields a carbo-hydrogen, helenéne, = $C_{15}H_8$, which is helenine — 2 at. water. With sulphuric acid, helenine forms a new acid, which, on account of its easy spontaneous decomposition, could not be examined.

Asarine, obtained by distilling the root of *Asarum Europæum* with water, is a crystallized solid, with an aromatic taste and smell like those of camphor, fusible in boiling water, and softened by the heat of the hand. Its sp. g. is 0·95. It sublimes unchanged when heated to about 570°. Its formula, according to Blanchet and Sell, is $C_{16}H_{11}O_4$; and these chemists consider it as the hydrate of an oil contained in the root, which they extracted by means of absolute alcohol. Their analysis of the oil, however, does not agree with this view.

Nicotianine is a fatty substance, obtained in minute quantity by distilling tobacco leaves with water. It is insoluble in water; soluble in alcohol, ether, and potash. It has a bitter taste, and a strong smell of tobacco.

Anemonine occurs in *Anemone pulsatilla*, *nemorosa*, and *pratensis*. It is crystalline, heavier than water, and, when heated in a current of air, sublimes with a pungent acrid smell, but cannot be distilled unchanged in close vessels. According to Löwig, its formula is $C_7H_3O_4$. He found it soluble in ether. But Fehling states that it is very sparingly soluble in that menstruum, and soluble in hot alcohol. Four analyses by Fehling give the formula $C_5H_2O_2$. By boiling it with oxide of lead and water he obtained a compound which seems to be $C_{15}H_6O_6,PbO$. By the action of baryta Löwig obtained an acid, Anemonic acid, the formula of which he states to be $C_7H_4O_3,HO$.

The pods of *Epidendron Vanilla* yield a crystalline body in soft needles, and the wood of *Quassia amara* also contains a crystalline body. Neither of these has been much studied. The seeds of *Tanghinia Madagascariensis* yield to ether a crystalline substance, which is highly poisonous.

According to Bonastre, Massoy bark contains a camphor-like substance, along with two volatile oils.

Hünefeldt has shown that the root of *Primula auricula* contains a volatile crystalline body, which has an odour resembling that of peppermint; and that the root of Primula veris yields another, which smells like fennel and garlic. He calls them Auricula camphor and Primrose camphor.

Cantharidine is a volatile crystalline body, contained in the insects Lytta ruficollis, L. gigas, and L. vittata. It is very soluble in ether, alcohol, and essential oils, and is volatile. It is the source of the blistering power of the insects. Regnault found it to be composed of $C_{10}H_6O_4$.

CAOUTCHOUC.

This remarkable substance, which has some analogy with the resins, occurs in the form of bottles, which are made by allowing the juice of the trees which yield it to flow from incisions on shapes of unburnt clay, which are broken when the caoutchouc has attained a sufficient thickness.

Caoutchouc is obtained from several trees, both in Asia and America, and particularly from *Siphonia elastica*, *Tabernæmontana elastica*, and *Lobelia caoutchouc*. The former has been variously named, and is known as *Jatropha elastica*, *Hevea Guianensis*, *Siphonia cahuchu*. The second named plant, *Tabernæmontana* has also been named *Urceola elastica*. Several species of *Ficus*, and many other plants, contain it likewise.

The juice is sometimes imported in closely stopped vessels. It is yellowish and thick, like cream; and has a sour smell, arising from the putrefaction of the vegetable albumen it contains. This albumen is coagulated by heat, and thereby causes the separation of the suspended caoutchouc. According to Faraday, the juice contains, in 100 parts, 32 of caoutchouc, 2 of vegetable albumen, 7 of a nitrogenised substance soluble in water, 3 of a substance insoluble in water, and 56 of water.

Pure caoutchouc is transparent and colourless, the black colour of the commercial article being derived from the smoke in which it is dried. It is perfectly elastic, and, when suddenly stretched, gives out much heat and free electricity. It is a nonconductor of electricity. When it has once separated from the juice in the solid form, there is no method known of obtaining it again suspended as before. In hot water it swells and becomes soft, but is utterly insoluble both in water and alcohol. Pure ether dissolves it, and leaves it by evaporation in a perfectly elastic state, and with a surface like that obtained by cutting it, when it has the property of adhering firmly to another similar surface if the two be strongly pressed together. This property enables us to form tubes from a plate of caoutchouc by folding it round a cylinder, cutting off the superfluous edges with a clean and sharp pair of scissors, and then pressing together the fresh cut edges. Tubes thus made are perfectly air and water tight. In rectified naphtha from wood or coal tar, caoutchouc is soluble; and the water-proof cloth of Mackintosh is made with a viscid solution in a mixture of oil of turpentine and coal naphtha, the solvent being removed by evaporation in chambers heated by steam, and leaving the caoutchouc with all its properties. Essential oils will also dissolve it alone; but from the presence in them of resin, which remains after evaporation of the oil, the caoutchouc does not dry properly, but remains viscid.

Heated to 248° it melts, and continues long viscid and soft. In this state it may be used as a luting, where a high temperature is not employed.

When more strongly heated, it is decomposed, and the greater part distils over in the form of a mixture of oily liquids. These differ extremely in volatility; the most volatile portion boiling about 90°, the least volatile at 680°, and the greater portion at intermediate temperatures. According to Himly, all these oils have the empirical formula C_5H_4, which is that of oil of turpentine. Gregory found a portion which boiled at 97° to have very nearly the composition of olefiant gas, C_2H_2; and, when this oil was acted on by sulphuric acid, it blackened, gave off sulphurous acid, and, on the addition of water, yielded an oil which boiled at a temperature above 428°, but still having the same composition.

By careful rectification Himly obtained an oil, the boiling point of which was constant at 339°, which he calls Caoutchine. It had the composition of oil of turpentine. Bouchardat, by applying intense cold to the receiver, obtained a liquid, Caoutchéne, which boiled below 32°, and is probably identical with Faraday's quadricarburetted hydrogen, C_4H_4. He also analysed another oil, Heveéne, boiling at 599°, which had the same composition. From the experiments of Himly, Bouchardat, and Gregory, therefore, it appears that caoutchouc by distillation yields many oily liquids, some of which have the composition of olefiant gas, and others that of oil of turpentine. The most volatile liquid above mentioned had the very low sp. g. of 0·654. Himly's caoutchine had the sp. g. 0·842.

The purest caoutchouc that Faraday could obtain from the juice was found by him to contain 87·2 p. c. of carbon, and 12·8 p. c. hydrogen.

RESINS.

This class of compounds occurs almost exclusively among vegetables. They either flow from them dissolved in essential oils, forming balsams, or are found deposited in the wood. What are called fossil resins are doubtless derived from extinct vegetation.

There is a close connection between resins and the oils in which they occur dissolved. All resins contain oxygen, and most essential oils become resinous by the absorption of oxygen from the air. It is not, however, probable, that resins are merely the oxides of essential oils. From the fact that iodine, a substance which has a very feeble attraction for hydrogen, acts strongly on essential oils, depriving them of a part of their hydrogen, it is obvious that that portion of hydrogen is in a different state of combination from the remainder; and it is most probable that the oxygen of the air removes this loosely combined hydrogen, forming water, while oxygen also replaces the hydrogen which has been removed. The water thus formed may either remain in combination with the new oxidised compound, or be separated.

Hence, when an essential oil is converted into resin by exposure to the air, the composition of the resin must be equal to that of the oil, *minus* a certain quantity of hydrogen, and *plus* a certain quantity of oxygen.

This appears to be the relation between common resin and oil of turpentine, and between the resin and oil of copaiva. Both of the oils are C_5H_4 or $C_{10}H_8$; and the resins are $C_{10}H_7O$, or, if we adopt the atomic weights as found by Rose, $C_{40}H_{28}O_4$. Here $C_{40}H_{32}$ have lost 4 eq. hydrogen, and gained 4 eq. oxygen. But the best analyses of these resins agree even better with the formula $C_{40}H_{30}O_4$. If this last be the correct formula, $C_{40}H_{32}$ have lost 2 eq. of hydrogen, replaced by 2 eq. oxygen, yielding the oxide $C_{40}H_{30}O_2$; and this oxide has then combined with 2 eq. oxygen, giving the rational formula $C_{40}H_{30}O_2 + O_2$.

If from this we reason backwards to the constitution of oil of turpentine, it will appear that that oil is $C_{40}H_{30} + H_2$ or $C_{20}H_{15} + H$, in which formulæ part of the hydrogen belongs to the radical, and the remainder is removable and replaceable by other elements, such as oxygen, iodine, or chlorine. This would also account for the tendency of oil of turpentine, as the hyduret of a compound radical, to unite with hydrochloric acid, the hyduret of a simple radical; just as ammonia, the hyduret of amide, or olefiant gas, the hyduret of acetule, unite with the same acid.

From the balsams, which, as already mentioned, are mixtures of resins with essential oils, the former are obtained pure by distillation with water, as long as any oil passes over.

There are distinguished hard and soft resins. The hard resins are brittle, colourless when pure, although often tinged yellow or brown by foreign matters. They are heavier than water, and non-conductors of electricity. When warmed, they have a slight odour, probably arising from traces of oil. Those which are insoluble in water are tasteless; many, which are sparingly soluble, have a bitter taste. They soften in boiling water, but generally require a higher temperature to melt them. They are decomposed by a strong heat, yielding combustible gases and volatile combustible liquids, with a residue of porous charcoal. They are easily inflammable, and burn with a smoky flame. When acted on by nitric acid, the resins yield oxalic acid, and a series of products not yet examined.

The resins occurring in nature are generally mixtures of several, differing in their characters. Some are exceedingly soluble in cold alcohol; while others are dissolved with difficulty, even by boiling alcohol. Several resins may be obtained in crystals from their alcoholic solutions; and the addition of water to all such solutions precipitates the resin, giving the mixture a milky aspect.

Many resins are soluble, others insoluble, in ether. They dissolve in fixed and essential oils, and also in sulphuret of carbon. The action of alkalies distinguishes one class of resins from another. A certain number, when dissolved, redden litmus, combine with bases, and possess all the characters of acids. Others are neutral, and do not combine with bases.

The most decidedly acid resins decompose the carbonated alkalies with the aid of heat, and readily dissolve in caustic alkalies. Their solution in alcohol is not precipitated by ammonia, and the precipitate caused by water is entirely soluble in ammonia. The alcoholic solution of the neutral resins is precipitated by ammonia.

The acid resins when dissolved in ammonia cause a crystalline precipitate in nitrate of silver, which is insoluble in excess of ammonia. The neutral resins cause no such precipitate.

The compounds of the acid resins with alkalies are called resinous soaps; but they cannot, like true soaps, be separated from their solutions by common salt, and when concentrated they do not form mucilaginous or gelatinous solutions, as soaps do. These solutions, however, froth when agitated, like a solution of soap. Some of these resinous soaps are insoluble in caustic potash, others soluble.

Common Resin, or *Rosin*, is obtained from the turpentine or balsam of Pinus sylvestris, pinaster, abies, and picea, by distillation with water till all the oil is removed. It is also named Colophon or Colophonium. It is nearly white when pure, (Resina alba,) but is commonly yellow or brown. It is a mixture of three acid resins, Sylvic, Pinic, and Colopholic acids.

Sylvic Acid is extracted from the resin by weak alcohol, and purified by stronger alcohol. It crystallizes in minute prisms, which lose no weight when heated to 212°. With alkalies it forms salts which are soluble in ether and alcohol.

Formula, $C_{20}H_{15}O_2$ (Trommsdorff), or $C_{20}H_{16}O_2$ (Rose).

Pinic Acid is left undissolved by alcohol of 72 p. c. It is purified by combining it with oxide of copper, which is done by adding acetate of copper to its solution in strong alcohol. The pinate of copper is decomposed by hydrochloric acid, and the pinic acid repeatedly boiled with water. It does not crystallize, but in other respects is analogous to sylvic acid. Its formula is $C_{20}H_{15}O_2$ (Liebig).

Colopholic Acid is produced by distilling pinic acid, and has a brown colour, but the same composition, and a stronger affinity for bases. When colophon has been strongly heated, part of the pinic acid is always converted into colopholic acid, so that it is present in that substance in variable quantity.

In the turpentine of *Pinus maritima* Laurent has discovered another acid, *Pimaric acid*, which is isomeric with the preceding acids, and which crystallizes from hot alcohol. By distillation in vacuo it yields another isomeric modification, *Pyromaric acid;* and, by the action of nitric acid, a third acid, *Azomaric acid*, the formula of which is $C_{20}H_{11}NO_8$. When pimaric acid is distilled under the ordinary pressure, it yields a neutral substance, *Pimarone*, which contains 1 at. of water less.

Fremy, by distilling resin with lime obtained two oils, Resinone and Resinéone; the former of which is $C_{10}H_9O$, the latter $C_{29}H_{23}O$.

When common resin is repeatedly heated with water to dryness, it yields what is called pitch, shoemaker's rosin, or Burgundy pitch. A still stronger heat produces the black pitch used for naval purposes. When distilled, resin yields a large quantity of gas of good quality for illumination.

The ***Resin of Copaiva Balsam***, when purified from the essential oil, is a crystallizable acid resin, and has the same composition in 100 parts as Colophon or Camphor. According to Rose, its formula, deduced from its salts, is $C_{40}H_{32}O_4$.

The ***Resin of Elemi*** contains two, one of which is crystallizable, but both are neutral. Their composition is the same as that of the resins already described. The resin called Gum Animé, from ***Hymenæa Courbaril***, likewise contains two resins, which seem to have acid properties. The resin of Euphorbium seems to be identical in composition and in most of its properties with that of Elemi.

Gum Benzoin, the inspissated juice of ***Styrax Benzoin***, contains, besides benzoic acid and an essential oil, three resins, namely, resins alpha, beta, and gamma. The latter is acid, the two former neutral. According to Van der Vliet, their composition is as follows:

Resin Alpha $= C_{70}H_{42}O_{14}$
—— Beta $= C_{40}H_{22}O_9$
—— Gamma $= C_{30}H_{20}O_5$

It is obvious that resin alpha contains the elements of the other two; and in fact, if the original mixture be long enough boiled with carbonate of potash, the resin alpha disappears, while gamma is dissolved, and beta left.

Styracine.—The balsams of Mecca and Peru, and storax, contain resin, essential oil, and, in the two latter, benzoic and cinnamic acids. The resins have been little examined; but Simon has extracted from storax a crystalline substance, which he calls Styracine. It is neutral, and has the properties of a resin. Its formula is $C_{24}H_{11}O_2$. Distilled with nitric acid, it yields hydrate of benzule, hydrocyanic acid, and other products. When distilled with hydrate of lime, it yields an oil, isomeric with benzine, but differing from it in properties; and, when distilled with aqua potassæ, it yields another oil, *Styraçone*, while the alkali is found combined with cinnamic acid, and mixed with a resinous matter. (Simon.)

Guaiacum, the resinous mass derived from *Guaiacum officinale*, contains a peculiar resin, distinguished by the property of striking a blue colour with many substances, such as mucilage of gum arabic, the roots of althæa, of cochlearia, of potatoe, of endive, of onions; also with nitrous acid, nitrous ether, and sweet spirit of nitre, as well as salts of iron and copper. The alcoholic tincture of guaiacum is the form in which this reaction is best observed. The guaiacum itself, by exposure to the air, becomes blue or green. It contains, besides more than one resin, not sufficiently studied, a bitter acrid substance, *Guaiacine*, the nature of which is uncertain. Guaiacum is used in medicine in the form of tincture, and in pills; and its compound with potash, called soap of guaiacum, is also employed.

Lac is obtained from punctures made by an insect in several species of Ficus, and also from Zicyphus jujuba. It occurs in three forms, stick, seed, and shell lac; the latter being the purest. It contains several resins, along with a peculiar colouring matter. It is an ingredient in the better kinds of sealing wax, and is much used for varnishes.

Mastic, from *Pistacia lentiscus*, and *Sandarac*, from *Juniperus communis*, grown in tropical regions, are two fragrant resins, containing each two or three different resins, and are also much used in making varnishes.

Copal, said formerly to have been derived from *Rhus copallanum*, seems by later accounts to be obtained from various species of *Hymenæa*, *Trachylobium*, and *Vouapa*. It has so much resemblance to amber, that it might be supposed to have a fossil origin; and, at all events, it has probably been long exposed to the action of the air before it has been collected. It is, of all resins, that which makes the finest varnishes, but it is at the same time the most difficult to dissolve. It may be dissolved in absolute alcohol, by first acting on it with aqua ammoniæ, which softens it into a gelatinous mass, and then adding the alcohol in small portions, with the aid of heat. It may likewise be dissolved in alcohol after being softened with ether. It is somewhat soluble in oil of rosemary, less so in oil of turpentine. But the common copal varnish is made by melting it cautiously, and adding oil of turpentine, heated to a certain point. According to Unverdorben, copal contains not less than five different resins, with a trace of essential oil.

The resin called *Dammar*, lately introduced, is derived from some unknown tree. It resembles copal, and makes excellent varnish.

Other resins, of whose chemical characters little is known, are Dragon's blood, from *Dracena Draco*, Takamahaka, Ladanum, the resin of Jalap, the root of *Convolvolus Jalappa*, that of Scammony, from *C. scammonium*, that of castor, that of birch bark, &c.

The following plants likewise contain resinous substances; *Iris florentina, Piper nigrum, Capsicum annuum, Pimpinella saxifraga, Helleborus hyemalis, Arnica montana, Anthemis pyrethrum, &c.*

RESINOUS VARNISHES.

These varnishes are made by dissolving resins in strong alcohol, or oil of turpentine. The resins principally used for varnishes are mastic, sandarach, shell lac, elemi, and copal. To dissolve the latter, it is melted, mixed while hot with a little drying oil, and to the mixture oil of turpentine, in quantity equal to the resin, is added by small portions. Spirit varnishes are more brittle, those with oil of turpentine more plastic, as the oil itself in drying yields a soft resin.

PRODUCTS OF THE DISTILLATION OF COMMON RESIN.

When resin is subjected to heat in close vessels, it yields a large quantity of gaseous carbo-hydrogens, and several liquids, also composed of carbon and hydrogen. The subject has been investigated by Frémy, and by Pelletier and Walter.

Frémy states, that, when distilled at the lowest possible temperature, resin yields, besides water and other products, an oily liquid, Resineine, the formula of which is $C_{20}H_{15}O$.

When distilled at a higher temperature, there is obtained, according to Pelletier and Walter, a liquid, Retinaphtha, the formula of which is C_7H_4. Treated with chlorine, retinaphtha yields a compound, $C_{14}H_6Cl_2$; and a similar compound may be formed with bromine. Along with retinaphtha there is formed another liquid, less volatile, Retinule, the formula of which is C_9H_6; and in the more fixed and oily product of the distillation of resin there are found a liquid, Retinole, the formula of which is C_8H_4, and a solid compound, in appearance like a crystalline fat, which is called Metanaphthaline or Retistérene, and which has the composition of naphthaline.

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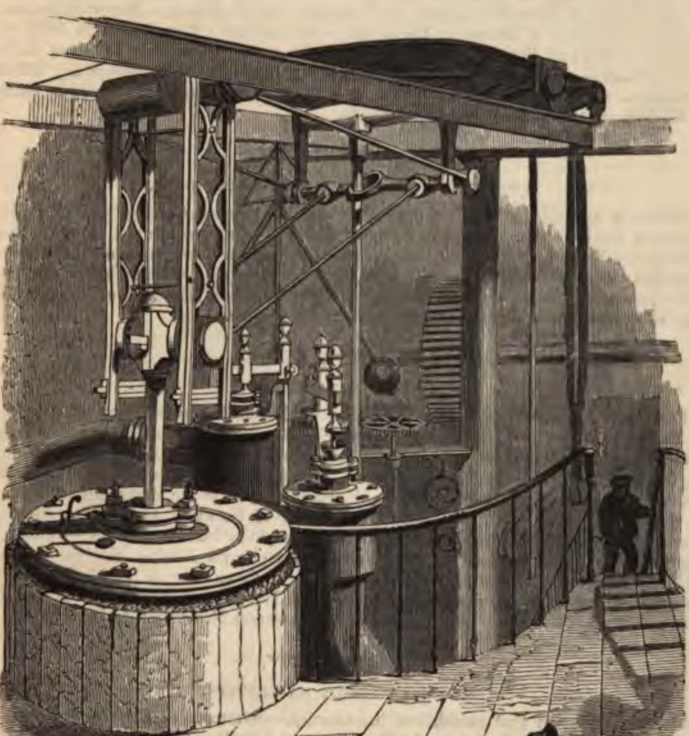

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